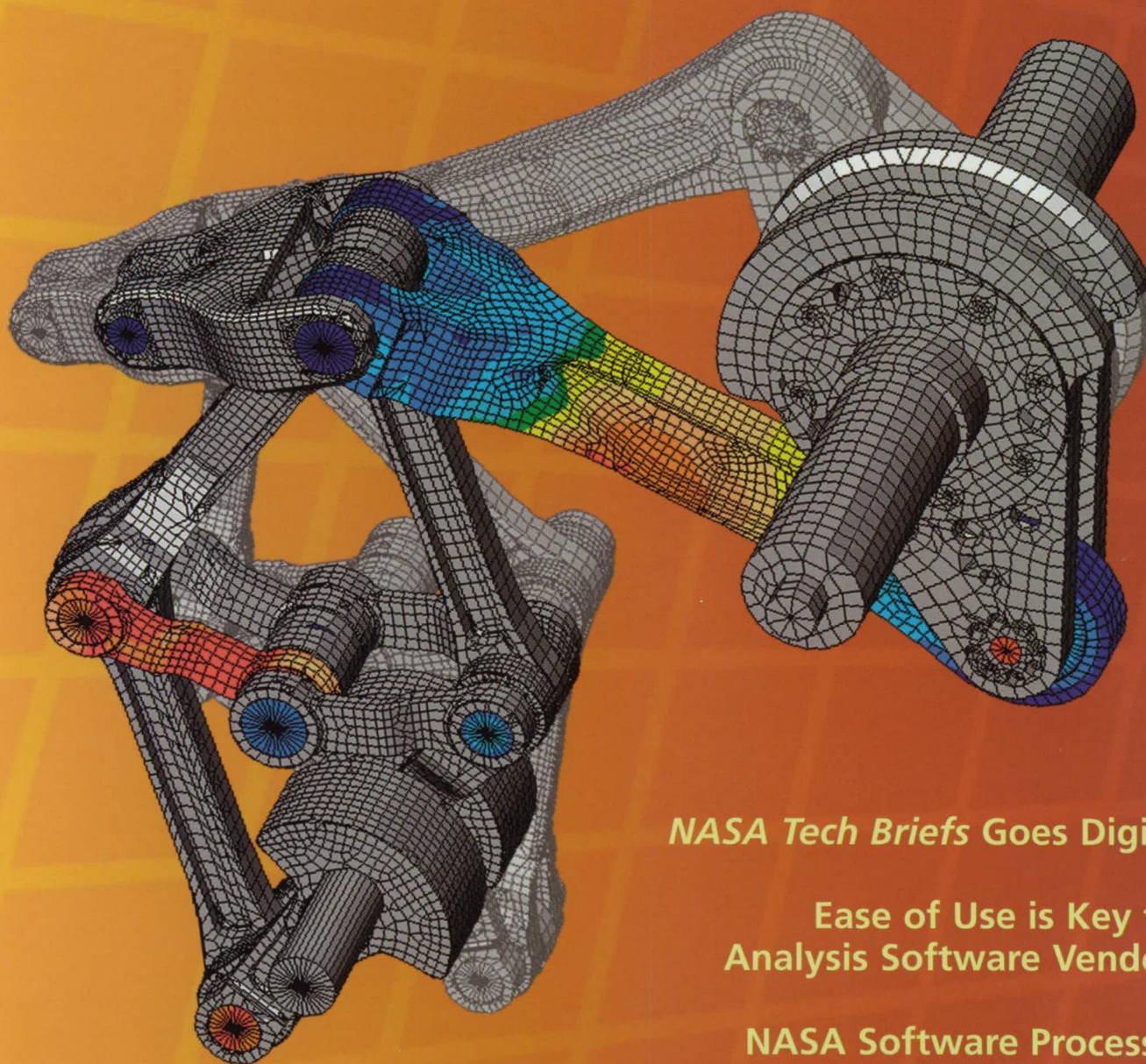




# TECH BRIEFS

ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING



*NASA Tech Briefs Goes Digital*

*Ease of Use is Key for  
Analysis Software Vendors*

*NASA Software Processes  
Data Into 3D Images*

*Photonics Tech Briefs*

JOHN F. KENNEDY  
SPACE CENTER LIBRARY  
DOCUMENTS DEPARTMENT  
REFERENCE COPY

-1-

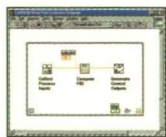
ID1/LIBRARY-D  
RM. 1124  
KSC HQS





For A Good  
Real-Time  
Call 800-890-6229

**No other real-time product delivers an integrated platform like LabVIEW™ Real-Time.**



Don't spend time building every real-time system from scratch. Use National Instruments integrated solution for a flexible, high-quality test platform for designing and prototyping even the most demanding aerospace, avionics, automotive, and biomedical applications. Rapidly create custom systems that integrate a wide variety of measurement and automation devices including:

- High-speed analog I/O
- Motion control
- GPIB
- Counter/timer I/O
- Digital I/O
- Serial/RS-232
- CAN

**[ni.com/info](http://ni.com/info)**

Call or visit [ni.com/info](http://ni.com/info) and enter na6s04  
for your free Real-Time Product Guide.



**(800) 890-6229**

Fax: (512) 683-9300 • [info@ni.com](mailto:info@ni.com)



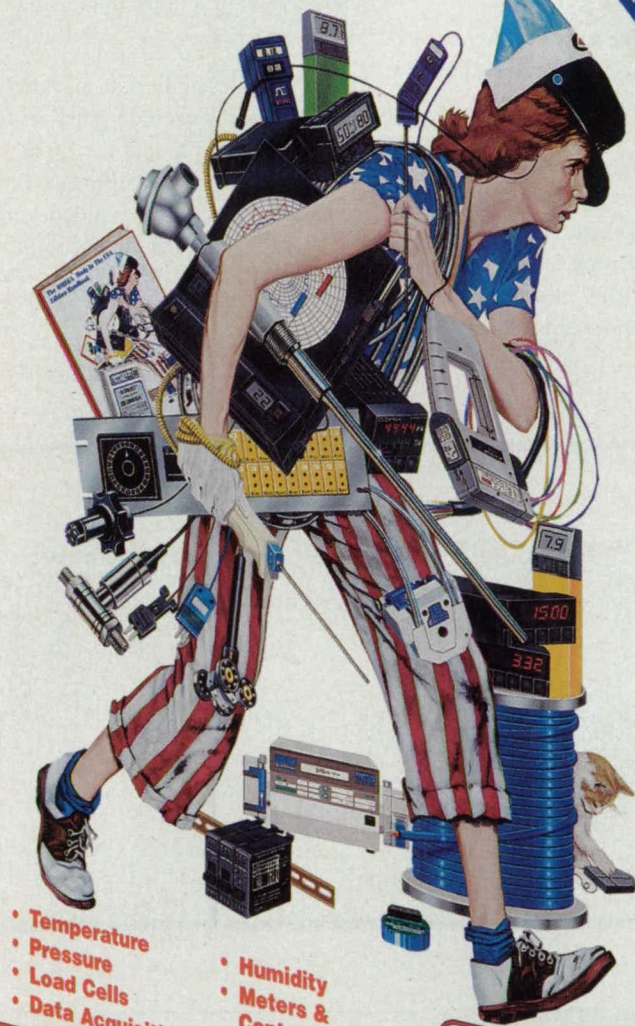
# All Your Process Measurement & Control Needs – **Made In The USA!**

**COMING  
SOON**

**Reserve Your  
Copy Today!**

**The OMEGA® Made In The USA  
Edition Handbook**

**MADE  
IN THE  
USA EDITION**



- Temperature
- Pressure
- Load Cells
- Data Acquisition

- Humidity
- Meters & Controllers
- pH & Conductivity

**omega.com®**  
— OMEGA® —



omega.com  
supports

OPERATION  
**ENDURING  
FREEDOM**

**OMEGAfax™**  
Document #2000  
**ONLINE:**  
[imadeintheusa.net](http://imadeintheusa.net)  
Circle #501

**THIS BOOK IS NOT FOR SALE™**

*It's FREE to people like yourself, who need to know!*

**OMEGAfax™** 24-Hour-a-Day On-Demand Publishing System – Call 1-800-848-4271  
to request product information. Simply enter the document number associated with the item.

- ✓ Temperature
- ✓ Pressure
- ✓ Load Cells
- ✓ Data Acquisition
- ✓ Humidity
- ✓ pH & Conductivity
- ✓ Panel Meters
- ✓ Controllers
- ✓ Recorders
- ✓ Flow
- ✓ Thermocouples
- ✓ RTD's
- ✓ Thermistors
- ✓ Connectors
- ✓ Level

**Order Online!**

**Over 100,000 Products!  
Made In The U.S.A.**

**2,000 Page Hardbound  
Color Handbook With Prices**

**1-888-82-66342<sup>SM</sup>  
1-888-TC-OMEGA**

**e-mail: [info@omega.com](mailto:info@omega.com)**

©COPYRIGHT 2001 OMEGA ENGINEERING, INC. ALL RIGHTS RESERVED.

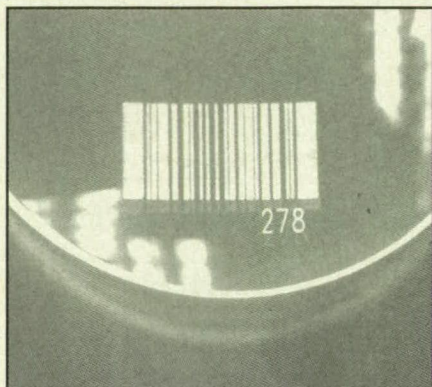




## CO<sub>2</sub> Laser Applications of the Month



### ▲ Marking Bar Codes on Glass with CO<sub>2</sub> Lasers



**128 Code**, marked with Synrad's galvo-based Laser Marking Head and 25W sealed CO<sub>2</sub> laser. Marking speed was 35" per second.

A new milestone in the development of glass marking techniques has been reached - laser marking readable 1-D bar codes on glass with sealed CO<sub>2</sub> lasers! Because bar codes require about 80% contrast to read, they are a challenge to laser mark on many materials, including glass. However, research in Synrad's applications lab has led to the development of two techniques to produce consistent, readable bar codes on this difficult material. One is accomplished by laser marking solid lines on the glass; the other by creating lines comprised of closely spaced spots.

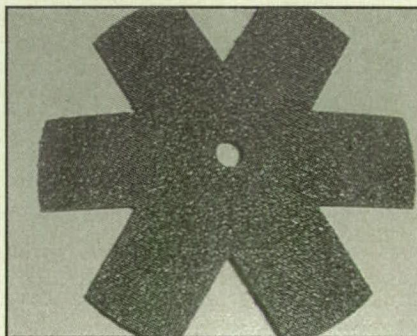


Magnified view of a code made up of linear spots.

Generally, the method of marking continuous lines is used on glass with a smooth surface finish, and the "spot" technique with less pristine surface finishes. The use of spots also aids illumination by increasing the scattering of light as it is refracted through the mark. Although the codes require a vision system to be read, set-up is straightforward with illumination provided by a luminescent lamp.

### ▲ Laser Cutting Sandpaper

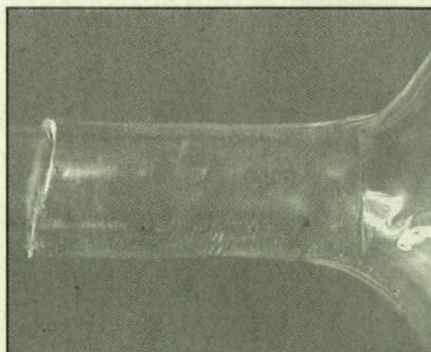
The thickness and abrasive nature of the aluminum oxide is a challenge for mechanical cutters, often resulting in tool wear and deformation of the paper. A sealed CO<sub>2</sub> laser cuts the sandpaper with no visible signs of thermal damage, and, as in the example at right, offers the end-user the flexibility to create custom shapes.



**This 0.04" aluminum oxide paper** was cut with a Synrad 125-watt sealed CO<sub>2</sub> laser at 125"/minute.

### ▲ Shrink Welding Nylon

To fabricate a medical device, a thin nylon balloon needed to be welded to a plastic tube. This was accomplished by using a heavily defocused CO<sub>2</sub> laser beam, and rotating the balloon and tube. The action of the beam caused the balloon end to constrict onto the tube, producing a mechanically strong weld.



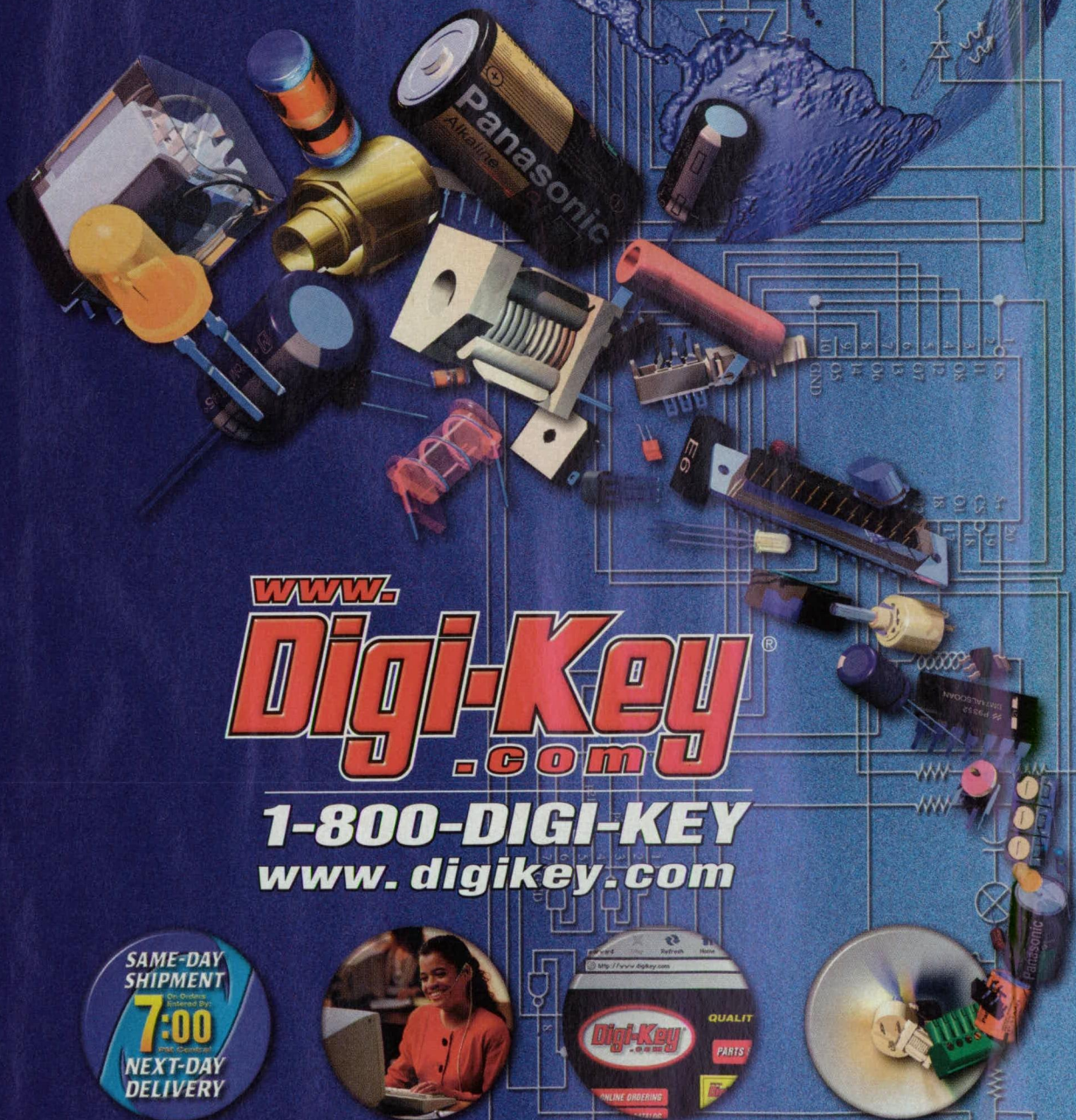
0.08"- diameter nylon tubing.

**Discover more CO<sub>2</sub> laser applications!**  
Sign up for our monthly online  
Applications Newsletter at  
[www.synrad.com/signup1](http://www.synrad.com/signup1)

*All applications on this page were processed at Synrad's Applications Laboratory. Synrad, the world's leading manufacturer of sealed CO<sub>2</sub> lasers, offers free process evaluations to companies with qualified applications. Call 1-800-SYNRAD1 for more information.*



# WORLD-CLASS SERVICE!



**www.**  
**Digi-Key®**  
**.com**

**1-800-DIGI-KEY**  
**www.digikey.com**



**#1**  
**On-time Delivery**



**#1**  
**Customer Service**



**#1**  
**Web Site**



**#1**  
**Availability of Product**



# In the world of CAD/CAM,



## VX Overdrive™. Premium-performance CAD/CAM



### ***Design through manufacturing with no stops***

VX® blows the doors off of  
CAD/CAM with a value-priced,  
design-through-manufacturing

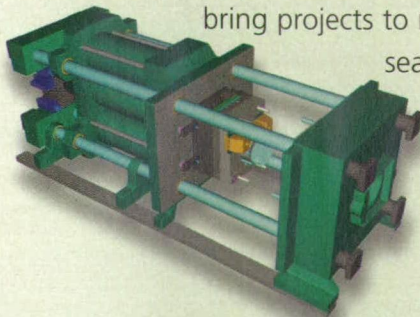
system so superior it leaves everything  
else in the dust. New VX Overdrive is so  
feature-rich, so fun to drive, what used  
to be roadblocks at every phase now  
become thrilling curves you can  
negotiate with ease.

### ***So easy to use***

VX Overdrive is loaded with flexibility to help you  
fly through even the toughest jobs. Unique surface  
creation tools let you blast through challenges at  
high speed. And its full integration from design  
through manufacturing means engineers can

bring projects to market faster using a single,  
seamless system. With VX

Overdrive, if you can imagine  
it, you can build it.





# we're changing the rules.



that's fun to drive.

***Premium performance  
without the premium price***

VX Overdrive comes fully loaded so you'll get the most bang for your buck of any system, plus the ability to import legacy data and the highest level of interoperability on the market (STEP, IGES and direct CAD translators).



***Take a test spin***

See for yourself how VX Overdrive is changing the rules. Contact us for a demo today.



**VX<sup>®</sup>** Shaping the future of CAD/CAM<sup>™</sup>

**VX.COM 321-676-3222**

For Free Info Circle No. 546 or Enter No. 546 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

©2001, VX Corporation. VX Overdrive and the VX logo are trademarks of VX Corporation.





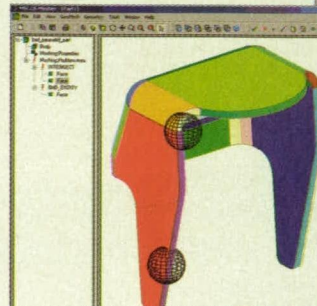
### FEATURES

- 25 Ease of Use is Key for Analysis Software Vendors**
- 30 InReview**

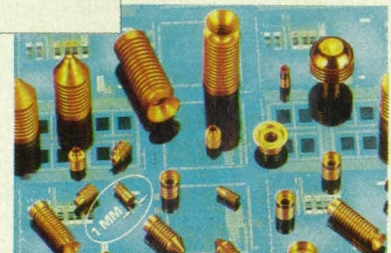
### SOLUTIONS

- 32 Special Coverage: Data Acquisition**
  - 32 Saturation Technique for Rapid Binary Image Processing
  - 34 Network for Forecasting Weather and Diffusion of Toxins
  - 35 Software for Processing Serial Cross Sections Into 3D Images
  - 36 Software for Displaying and Comparing Wind-Tunnel Data
  - 36 Integrated Environmental Monitoring Instrument
  - 38 Profiling the Atmosphere by Use of an Elevated GPS Receiver
- 40 Electronic Components and Systems**
  - 40 Improved Model of Spectral Response of an HEB Mixer
  - 40 Improved Charge-Termination Technique for Lithium-Ion Cells
  - 42 Equipment for On-Wafer Testing at Frequencies Up to 220 GHz
- 46 Software**
  - 46 Software for Ground Operations for a Prototype Mars Rover
  - 46 Software Processes SRTM ScanSAR Data Into Topographical Maps
  - 48 Algorithm for Autonomous Visual Discovery
  - 48 Computer Program Generates Test Cases
  - 50 Software Manages Documentation in a Large Test Facility
  - 50 Software Performs Testing, Monitoring, and Control Functions
- 51 Materials**
  - 51 Relatively Simple Atmospheric-CO<sub>2</sub> Controller
  - 51 A Technique for Injecting Ag<sup>+</sup> Ions as Biocide into H<sub>2</sub>O
- 52 Machinery/Automation**
  - 52 Breathing-Air and Cooling Apparatus for Protective Suit
  - 53 Thermoelectric Contact Cooler/Freezer
- 54 Physical Sciences**
  - 54 Molten-Carbonate Electrolyzers for Making CO and O<sub>2</sub>

25



30



58

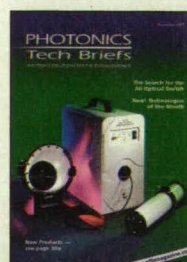
### DEPARTMENTS

- 14 UpFront**
- 16 NASA Patents**
- 18 Reader Forum**
- 20 Technologies of the Month**
- 22 Who's Who at NASA**
- 24 Commercial Technology Team**
- 66 Advertisers Index**

### NEW FOR DESIGN ENGINEERS

- 58 Products/Software**
- 60 Literature**

### SPECIAL SUPPLEMENT



#### 1a - 30a Photonics Tech Briefs

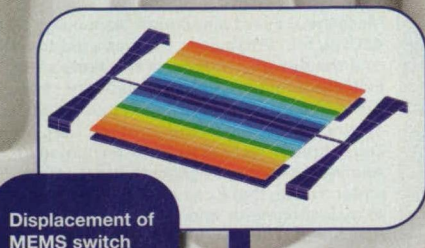
*Follows page 50 in selected editions only.*



# ALGOR SIMULATES MEMS

Visit [simulatemems.algor.com](http://simulatemems.algor.com)

and watch our free educational Webcast demonstrating how ALGOR software simulates MEMS.



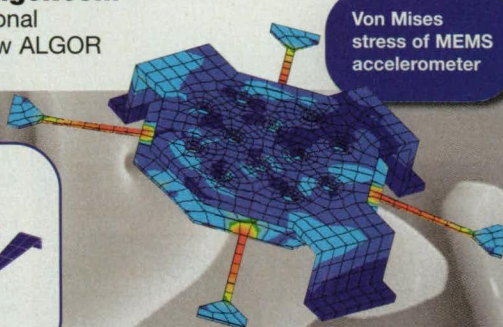
Displacement of  
MEMS switch



MEMS switch  
compared to  
a penny

## WHAT ARE MEMS?

Micro Electro Mechanical Systems (MEMS) are micromachines the size of a grain of salt or the eye of a needle that integrate mechanical elements, sensors, actuators and electronics on a common silicon substrate. MEMS applications include optical switches within telecommunication and networking systems, accelerometers in automotive airbags, inkjets in desktop printers and sensors in medical testing equipment. The emerging MEMS industry promises to make the next generation of electronic products smarter and cheaper.



Von Mises  
stress of MEMS  
accelerometer



Electric field of  
MEMS radial  
comb motor

ALGOR's direct-selling and high-technology business model delivers the best FEA-based simulation value for MEMS simulation in the CAE industry. ALGOR's MEMS solution links electrostatic analysis to structural analysis tools with an easy-to-use graphical user interface that works within many popular CAD systems and includes a precision FEA model building tool.

## ALGOR'S MEMS SOLUTION INCLUDES:

- Multiphysics analysis software to simulate the real-world mechanical behavior for several physical factors acting simultaneously, such as:
  - Electrostatic analysis software that calculates forces due to surface charges
  - Mechanical Event Simulation for virtual replication of dynamic events with linear and nonlinear material models that predicts electromechanical effects driven by electrostatic forces
  - Structural analysis software that predicts electromechanical effects driven by electrostatic forces
  - Piezoelectric material models for Mechanical Event Simulation and static stress analysis
  - Composite material models for Mechanical Event Simulation and static stress analysis
  - Thermal analysis for considering the effects of heat transfer
  - Fluid flow analysis for considering the effects of fluid dynamics
- An easy-to-use graphical user interface that enables engineers to directly apply electrostatic forces to a structural model and provides right-click functionality for applying, modifying and removing loads, constraints and finite element properties
- Built-in precision FEA model building capabilities with geometric scaling and structured meshing capabilities
- InCAD technology for CAD/CAE interoperability within Autodesk Inventor, CADKEY, Mechanical Desktop, Pro/ENGINEER for Windows, Solid Edge and SolidWorks
- Unstructured brick and tetrahedral meshing
- A midplane mesh engine that automatically converts thin solid parts into plate/shell elements
- A Material Library Manager that controls material property data for all analysis types

**ALGOR**  
When Engineering Has to be Right



CADKEY  
SOLUTION PARTNER



PTC  
Enterprise  
Software  
Partner



SOLID EDGE  
PREMIUM  
VOTAGER  
MEMBER



Autodesk  
Registered Developer

150 Beta Drive  
Pittsburgh, PA 15238-2932 USA  
US Phone: 1.412.967.2700  
Fax: 1.412.967.2781  
Europe (UK): 44.1784.442.246  
California: 1.714.564.0844  
E-mail: [simulatemems@algor.com](mailto:simulatemems@algor.com)  
[simulatemems.algor.com](http://simulatemems.algor.com)



- 54 Improved Spherical Energy Analyzer
- 54 Redundant Oxygen-Deficiency Monitoring System
- 55 Thermal Detection of Gas in a Tube Containing Flowing Liquid



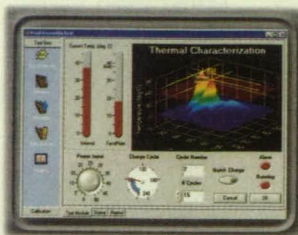
## 56 Books and Reports

- 56 Theory of Formation-Flying Control for Multiple Spacecraft
- 56 Self-Organization Based on Quantum Entanglement
- 56 Onboard Estimation of Times of Periapsis During Aerobraking
- 56 Report on User's Guide for Monthly Vector Wind Profile Model
- 57 Experiments on Residual-Stress Bondline Failures in an RSRM
- 57 Improved Micromachined Vaporizing-Liquid Microthruster
- 57 Sizes of Surface and Capped  $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{GaAs}$  Quantum Dots
- 57 Fuel Cell Would Generate Power From Martian Atmosphere

This document was prepared under the sponsorship of the National Aeronautics and Space Administration. Neither Associated Business Publications Co., Ltd. nor the United States Government nor any person acting on behalf of the United States Government assumes any liability resulting from the use of the information contained in this document, or warrants that such use will be free from privately owned rights. The U.S. Government does not endorse any commercial product, process, or activity identified in this publication.

## PRODUCT OF THE MONTH

Measurement Studio™ 6.0 software from National Instruments (Austin, TX) lets engineers create a variety of integrated test, measurement, and control applications in the programming language of their choice.



14

## ON THE COVER



Mechanical Event Simulation technology from ALGOR, Inc., Pittsburgh, PA, was used to replicate the dynamic motion of this Peaucellier Cell and simultaneously calculate the stresses caused by the motion. The geometry for the assembly was seamlessly captured from Solid Edge through ALGOR's InCAD technology. Analysis software, in general, is becoming easier to use, thanks to an effort by vendors to make engineers and designers more productive. See the feature beginning on page 25 for more on the issues facing analysis software providers and users.

(Image courtesy of ALGOR, Inc.)

Permissions: Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by Associated Business Publications, provided that the flat fee of \$3.00 per copy be paid directly to the Copyright Clearance Center (222 Rose Wood Dr., Danvers, MA 01923). For those organizations that have been granted a photocopy license by CCC, a separate system of payment has been arranged. The fee code for users of the Transactional Reporting Service is: ISSN 0145-319X/94 \$3.00+.00

# >MISSION CONTROL, WE HAVE A VISUAL

## IDL: THE LANGUAGE OF DATA VISUALIZATION

Work with our experts to develop that 'killer app' that gives you the competitive edge or use IDL to build your own custom applications in less time than with any traditional programming language.

- Create interactive Web-enabled applications using JAVA and IDL.
- Take your productivity to a new level with IDL's built-in multi-threading capabilities.
- Use the power of IDL to manipulate 1D, 2D, 3D or even 4D visualizations interactively.
- Develop a user interface in IDL, or use IDL as an ActiveX control.
- Call C, C++, FORTRAN code, or call IDL from your existing application.

Available for Window, UNIX, Linux, and Macintosh.



Call us today at 303.786.9900 or visit our website  
at [www.ResearchSystems.com/Aerospace](http://www.ResearchSystems.com/Aerospace) to find out more.





# AUTOBAHN FOR ENGINEERS



Step on it. High-performance, ultra-reliable Compaq Evo™ Workstations help move product designs to market with incredible speed. With the latest Intel® Xeon™ Processor technology, they're fully compatible with leading design programs preferred by leading CAD-ISV partners. Now every member of, say, an automobile design team can weigh in concurrently and integrate seamlessly with other business systems. And even complex CAD applications will run like a well-tuned engine.



The Power of  
MACROPROCESSING

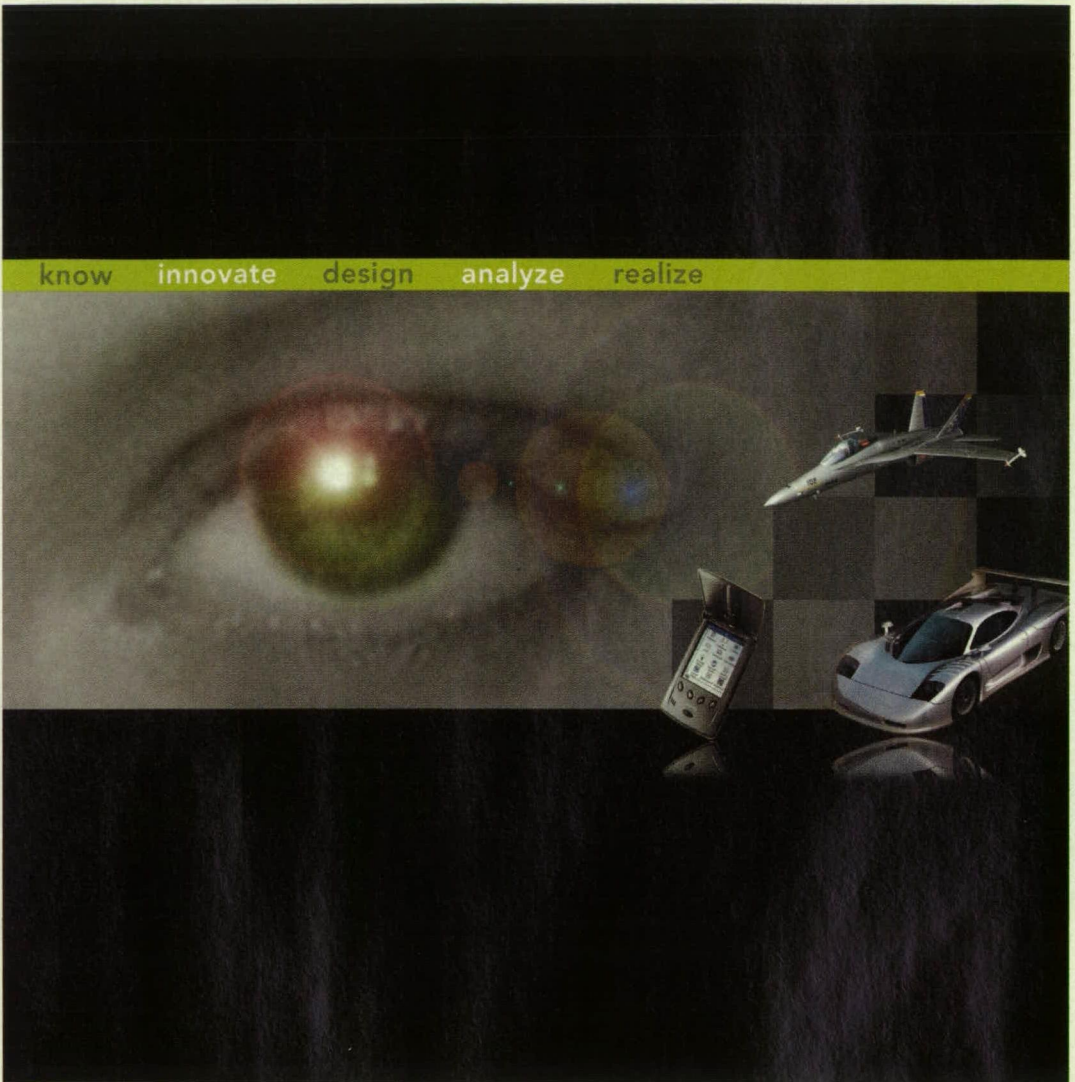
to find out more go to [compaq.com/workstations](http://compaq.com/workstations)  
or call 1-800-888-0414

Compaq PCs use genuine Microsoft® Windows®  
[www.microsoft.com/piracy/howtotell](http://www.microsoft.com/piracy/howtotell)

Compaq is not liable for editorial, pictorial or typographical errors in this advertisement. Compaq and the Compaq logo are registered in the U.S. Patent and Trademark Office. Evo is a trademark of Compaq Information Technologies Group, L.P. Inspiration Technology is a trademark of Compaq Information Technologies Group, L.P. in the U.S. and other countries. Intel, the Intel Inside logo, and Intel Xeon are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries. Products and company names mentioned herein may be trademarks and/or registered trademarks of other countries. © 2001 Compaq Computer Corporation.

**COMPAQ**  
Inspiration Technology







## Unigraphics – Making you uniquely successful.



Increase your productivity by 2-to-1, 3-to-1, even 10-to-1. Use the knowledge of experts in your industry. Automate your own best practices. Make your organization uniquely successful. With Unigraphics from EDS. The new Unigraphics helps you produce winning products, rapidly respond to market opportunities, capitalize on product innovation and generate value. Through the leading companies across industries, we learn about the best practices in product development. Rather than create software, we develop easy-to-use solutions that feature built-in knowledge, such as for moldmaking, strength analysis, die stamping, welding, etc. It's not about software. It's about you. Learn more – visit [www.unigraphics.com](http://www.unigraphics.com) or call 1-800-325-1551.







# COMBINE MULTIPLE COMPUTER & VIDEO SIGNALS ON A SINGLE SCREEN

**The SuperView  
Display Processor Offers  
Up to 10 Inputs in  
Real-time & Full Color**



Now you can display multiple live video and computer inputs on a single monitor or projector. With up to 10 simultaneous inputs, the SuperView™ processor offers a better alternative to videowalls and other arrays of monitors or projectors.

The SuperView is easily installed and compatible with virtually all PCs and workstations. Functions can be controlled from the front panel or remotely via the RS-232 port. Optional software offers controls under Windows 95/98/NT.

Designed for maximum flexibility, the SuperView system is an excellent solution for applications requiring large screen projection, remote video monitoring, command-and-control, simulation, teleconferencing and multimedia display.

**Resolution up  
to 1600 x 1200**

**Computer and  
video inputs**

**Independent scale,  
position & zoom**

**RS-232 control**

**Computer on  
video overlay**

**Visit our web site <http://www.rgb.com>**

**RGB SPECTRUM®**  
A visual communications company™

950 Marina Village Parkway  
Alameda, California 94501  
Tel: (510) 814-7000  
Fax: (510) 814-7026  
E-mail: [sales@rgb.com](mailto:sales@rgb.com)



For Free Info Circle No. 402 or  
Enter No. 402 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## TECH BRIEFS

[www.nasatech.com](http://www.nasatech.com)



Published by ..... Associated Business Publications  
Publisher ..... Joseph T. Pramberger  
Editor/Associate Publisher ..... Linda L. Bell  
Editor, Market Focus Editions ..... Robert Clark  
Associate Editor/Internet Editor ..... Laura Raduta  
Production Manager ..... Margery Koen  
Assistant Production Manager ..... John Iwanciw  
Art Director ..... Lois Erlacher  
Senior Designer ..... Christopher Coleman  
Circulation Manager ..... Hugh J. Dowling

**BRIEFS & SUPPORTING LITERATURE:** Written and produced for NASA by  
**Advanced Testing Technologies, Inc.**, Hauppauge, NY 11788

Technical/Managing Editor ..... Ted Selinsky  
Sr. Technical Analyst ..... Dr. Larry Grunberger  
Art Manager ..... Eric Starstrom  
Staff Writers/Editors ..... Dr. Theron Cole, George Watson  
Graphics ..... Robert Simons  
Editorial & Production ..... Joan Schmiemann, Becky D. Bentley

### NASA:

NASA Tech Briefs are provided by the National Aeronautics and Space  
Administration, Technology Transfer Division, Washington, DC:

Administrator ..... Daniel S. Goldin  
Director, Commercial Technology ..... Dr. Robert Norwood  
Publications Director ..... Carl Ray

### ASSOCIATED BUSINESS PUBLICATIONS INTERNATIONAL

317 Madison Avenue, New York, NY 10017-5391  
(212) 490-3999 FAX (212) 986-7864

Chairman/Chief Executive Officer ..... Bill Schnirring ([bill@abpi.net](mailto:bill@abpi.net))  
Vice Chairman/Chief Operating Officer ..... Domenic A. Mucchetti  
MIS Manager ..... Ted Morawski  
Webmaster ..... Albert Sunseri  
Director of Electronic Products ..... Luke Schnirring  
eStrategy Director ..... Andrew Runk  
Credit/Collection ..... Felecia Lahey  
Human Resources Manager ..... Lourdes Del Valle  
Accounting Manager ..... Sylvia Ruiz  
Office Manager ..... Alfredo Vasquez

### NASA TECH BRIEFS ADVERTISING ACCOUNT EXECUTIVES

Headquarters ..... (212) 490-3999  
CT, MA, NH, ME, VT, RI, Eastern Canada ..... Ed Marecki  
at (401) 351-0274  
NJ, NY, PA, DE ..... Jim Oot  
at (973) 316-9695  
VA, MD, DC, NC, SC, GA, FL, AL, TN, MS, LA, AR, OK, TX ..... Bill Manning  
at (770) 971-0677  
MN, ND, SD, WI, IL ..... Bob Casey  
at (847) 223-5225  
IN, KY, MI, OH, MO, KS, IA, NE, Western PA & NY, Central Canada ..... Chris Casey  
at (847) 223-5225  
N. Calif., CO, WA, OR, ID, MT, WY, UT, Western Canada ..... Bill Hague  
at (800) 830-4351  
S. Calif., AZ, NM, NV ..... Tom Boris  
at (949) 642-2785  
Internet Advertising ..... Luke Schnirring  
at (212) 490-3999  
Postcard/Literature Advertising ..... John Waddell  
at (212) 490-3999  
Reprints ..... Jeannie Martin  
at (219) 879-8366

**For a complete list of staff e-mail addresses,  
visit [www.abpi.net](http://www.abpi.net)**



**NEW  
PRODUCT  
RELEASE  
AVAILABLE  
NOW**

# What will you think of next?

Simulink® 4

**NEW** Simulink Performance Tools

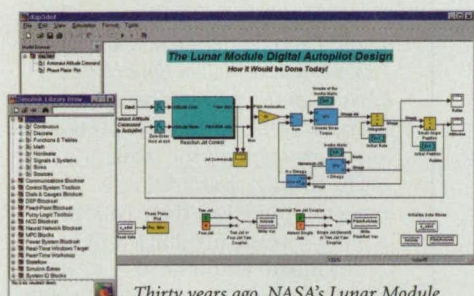
Stateflow® 4

Stateflow Coder 4

Real-Time Workshop® 4

**NEW** Real-Time Workshop Embedded Coder

New Simulink 4 is the model-based design solution that gives you the power



Thirty years ago, NASA's Lunar Module Autopilot took thousands of hours to design. Today, it could be done by one engineer in about a week using Simulink 4.

to explore, refine and realize your engineering designs in a fraction of the time needed for traditional methods. Powerful extensions let you design the logic in your systems and generate production-quality code automatically.

**Act now. Get data sheets, application examples, user stories, and product demos.**

Learn to build superior products in less time with Simulink. Get started at [www.mathworks.com/ntmb](http://www.mathworks.com/ntmb).

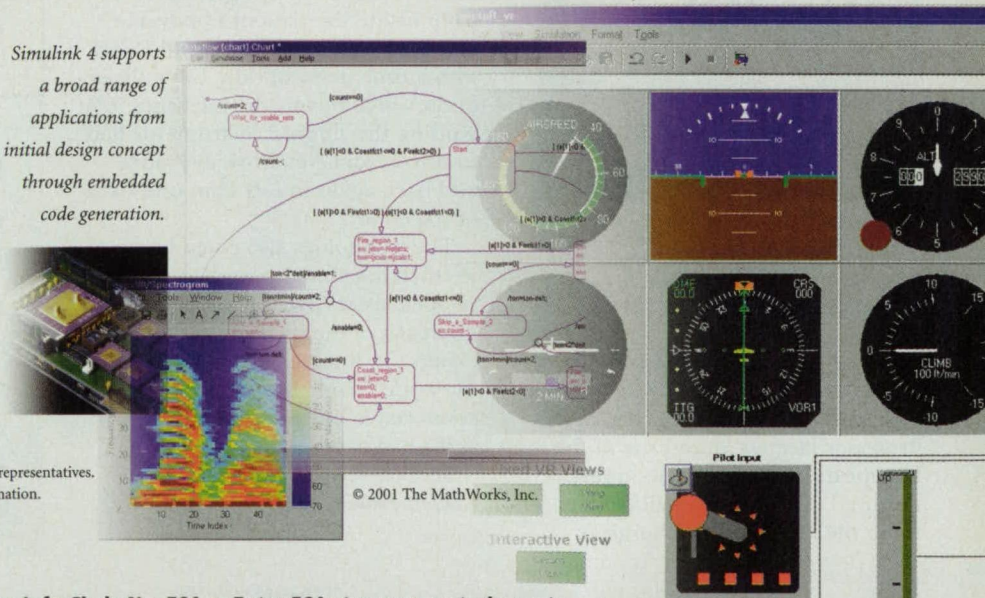
**MATLAB®  
& SIMULINK®**

Simulink 4 supports a broad range of applications from initial design concept through embedded code generation.

**The MathWorks**

Visit [www.mathworks.com/ntmb](http://www.mathworks.com/ntmb) or call 508-647-7040

We have a worldwide network of offices and international representatives. Visit our Web site at [www.mathworks.com](http://www.mathworks.com) for more information.

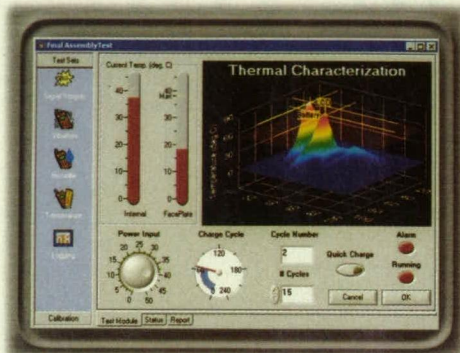




## PRODUCT OF THE MONTH

National Instruments, Austin, TX, has introduced Measurement Studio™ 6.0, a set of integrated measurement tools that engineers can use to create test, measurement, and control applications in various programming languages. The software supports LabWindows™/CVI, Microsoft Visual Basic, and Visual C++. Vision and motion hardware also can be integrated into measurement applications through task-oriented software. With the new version's visualization tools, engineers can display data on real-time 3D or 2D graphs and charts that can be annotated to explain significant dips or spikes in the data. The graphs and other data can be shared via DataSocket™, a publish/subscribe technology that provides simplified URL addressing. Real-time data can be viewed from a test that is occurring in another part of the world. Other features include signal analysis functions and interchangeable virtual instrumentation (IVI) class compatibility.

For Free Info Circle No. 750 or Enter No. 750 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## Robotic Surgery Spans an Ocean

Recently, a 68-year-old woman in Strasbourg, France, became the first patient in history to receive a complete surgical operation performed by surgeons in New York — nearly 4,000 miles away.



Prof. Jacques Marescaux (l) and Dr. Michel Gagner are seated at the controls of the Zeus Robotic Surgical System in New York, performing surgery on a patient in France. (Photo courtesy of Computer Motion)

Dr. Michel Gagner, chief of laparoscopic surgery at New York's Mt. Sinai Hospital's School of Medicine, and Professor Jacques Marescaux of the European Institute of Telesurgery, removed the woman's gallbladder using the Zeus® Robotic Surgical

System from Computer Motion of Santa Barbara, CA. Dr. Gagner manipulated the arms of his computer system in New York, and the instructions were transmitted via a high-speed fiber-optic service provided by France Telecom.

Dr. Gagner operated the laparoscope — a tubular surgical instrument — while receiving pictures from inside the patient's body. He and Professor Marescaux could work with a time delay of only 150 milliseconds, which means the messages guiding the surgical instruments had to travel from New York to France and back again in less than one-sixth of a second.

The technology also could be used to teach doctors who work in underdeveloped areas. "We can now extend the reach of the surgeon so that an expert can intervene any place in the world," said Marescaux. "I felt as comfortable operating on this patient as if I had been in the room."

For more information, visit [www.computermotion.com](http://www.computermotion.com).

## NASA Tech Briefs Goes Digital

Beginning with this issue of *NASA Tech Briefs*, you now have a choice of receiving a digital (pdf) version of the magazine in addition to or instead of your print copy. The pdf edition is a full-color replica of the printed magazine, with many added benefits, including the ability to search and archive digital issues, hyperlink directly from articles and ads to Web pages, and view embedded video and audio clips.

Plus, as a digital subscriber, you automatically will receive technology-focused supplements such as *Photonics Tech Briefs* and *Motion Control Tech Briefs*. And the pdf edition will be available earlier than you now receive your copy through the mail.

The average pdf edition is expected to be less than 10 MB, making it relatively quick and easy to download. You'll be able to view pages side-by-side and print them on demand.

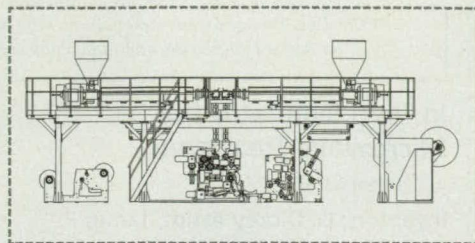
The pdf edition is free to qualified U.S. subscribers who switch from the print version. You can, however, receive both versions for a nominal service fee of \$2.00 per month, which helps cover our additional costs. Of course, you can continue to receive the print edition only at no charge — provided you renew your subscription annually.

Visit [www.nasatech.com/subscribe](http://www.nasatech.com/subscribe), and indicate which option you prefer, or fax back the subscription form in this issue.

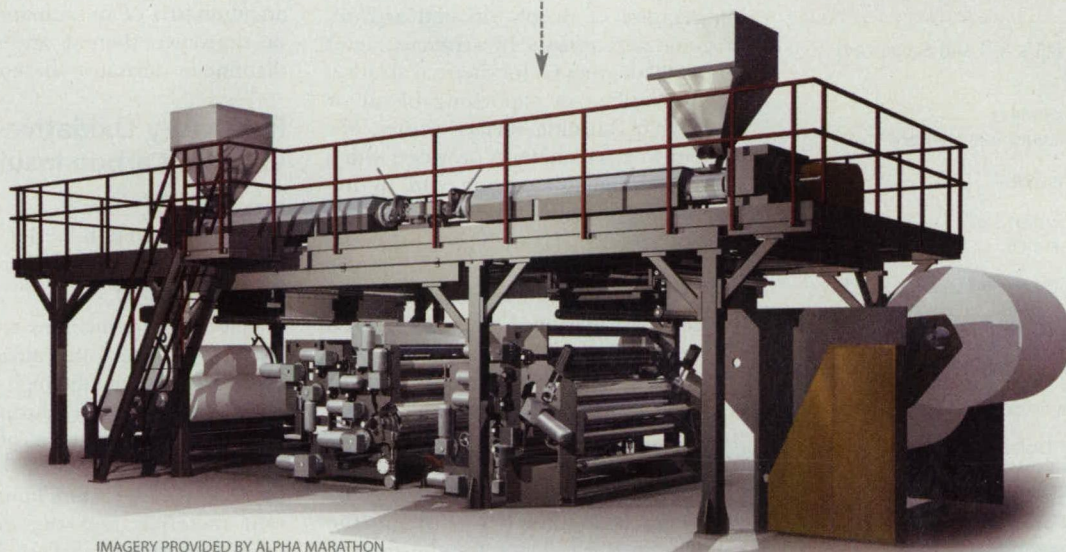
## Cast Your Vote

It's almost time to vote for the 2001 *NASA Tech Briefs* Readers' Choice Product of the Year Awards. Next month's issue will have the official rules and voting instructions you need to cast your vote for the most significant new product introduced to the engineering community this year.





**Go from 2D to 3D design without a detour through hell.**



IMAGERY PROVIDED BY ALPHA MARATHON

Don't get burned. Get **Autodesk Inventor™** software. It's the industry's biggest leap in 3D design technology in over 15 years, with breakthrough adaptive technology, exceptional large assembly performance, and industry-leading DWG compatibility. For Alfredo Bentivoglio, President of Alpha Marathon, "The transition from 2D to Autodesk Inventor was a breeze." And its intuitive nature will save you more than just time: "We'll save up to one million dollars by drastically reducing prototyping," he says. If you're ready for 3D the easy way, you're ready for Autodesk Inventor. Freedom to design without limits. Visit [www.autodesk.com/inventor](http://www.autodesk.com/inventor) to find out more.

**autodesk®**

© 2001 Autodesk, Inc. Autodesk and the Autodesk logo are registered trademarks, and Autodesk Inventor is a trademark, of Autodesk, Inc. in the U.S.A. and other countries.

For Free Info Circle No. 542 or Enter No. 542 at [www.autodesk.com](http://www.autodesk.com)



# 14 Bit 100 MS/s Scope with 1 Billion Points Acquisition Memory

1 GIGASAMPLE  
ACQUISITION MEMORY



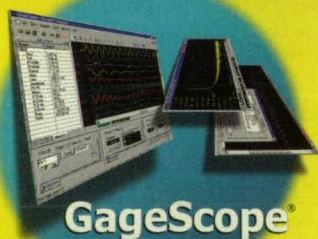
**CompuScope 14100**

- 14 Bit, 100 MS/s A/D and Scope card for PCI bus
- Up to 1 GigaSample On-board Acquisition Memory
- 50 MHz Bandwidth
- Multi-Card Systems of up to 16 Channels
- SDKs for C/C++, MATLAB & LabVIEW

#### Other Deep Memory models available

8 bit	500 MS/s Scope Card	2 GB Memory
16 bit	10 MS/s Scope Card	1 Gig Memory
32 bit	100 MHz Digital Input	2 GB Memory

**Compatible with GageScope®**



**GageScope®**

**World's Most Powerful  
Oscilloscope Software**

**GaGe**

A Tektronix Technology Company

**1-800-567-GAGE** ext:3405  
www.gage-applied.com/ad/nasa1101.htm

Outside the U.S. contact: Gage Applied, Inc.  
Tel: +1-514-633-7447 Fax: +1-514-633-0770  
e-mail: prodinfo@gage-applied.com

**For Free Info Circle No. 403 or  
Enter No. 403 at www.nasatech.com/rs**



# Patents

*Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:*

## In Vivo Simulator for Microwave Treatment

(U.S. Patent No. 6,175,768)

**Inventors:** G. Dickey Arndt, James R. Carl, George W. Raffoul, Vincent G. Karasack, Antonio Pacifico, and Carl F. Pieper, Johnson Space Center

This invention provides methods and apparatus operable for thermally ablating arrhythmogenic cardiac tissue to treat ventricular tachycardia, or rapid pumping of the heart ventricles, while controlling the temperature rise in nearby blood and heart tissues. The system can raise the temperature of deeply situated arrhythmogenic cardiac tissue by a sufficient level (about 20 degrees C) for thermal ablation without boiling or vaporizing blood or charring or burning surface tissues. For this purpose, a catheter is provided with a microwave radiator at one end. A frequency of operation is selected, between about 1 and 12 GHz or higher, so that a temperature increase from absorption of microwave energy in the blood is limited by the blood exchange rate to a desired temperature range. The catheter is positioned to place the microwave radiator adjacent and preferably in contact with the arrhythmogenic tissue. The radiator will therefore typically be surrounded by blood. A microwave signal of a selected frequency is conducted through the catheter to the radiator for the desired heating time.

## Polyimide Precursor Solid Residuum

(U.S. Patent No. 6,180,746)

**Inventors:** Erik S. Weiser, L. St. Clair, Yoshiaki Echigo, and Hisayasu Kaneshiro, Langley Research Center

Polyimide foam materials have a number of beneficial attributes for next-generation space vehicles, such as high temperature and solvent resistance, flame resistance, low smoke generation, high modulus and chemical and hot water resistance. Another area for polyimide foams is in the manufacture of low-density insulation for thermal and acoustic applications, and reinforcement for the maritime industry. The foamed products produced by cur-

rent methods often exhibit nonuniformity of density and cell size throughout the foamed structure, which results in low yields of acceptable product. Additionally, some of the polyimide precursors employed in related art processes, especially those involving isocyanate chemistry, have poor hydrolytic stability and poor stability toward other types of decomposition. The inventors have provided a polyimide precursor solid residuum that has particular utility and special effectiveness in the preparation of polyimide foam and the fabrication of polyimide foam structures. The residuum is an admixture of an aromatic dianhydride or derivative thereof and an aromatic diamine or derivative thereof.

## Refractory Oxidative-Resistant Ceramic Carbon Insulation

(U.S. Patent No. 6,225,248)

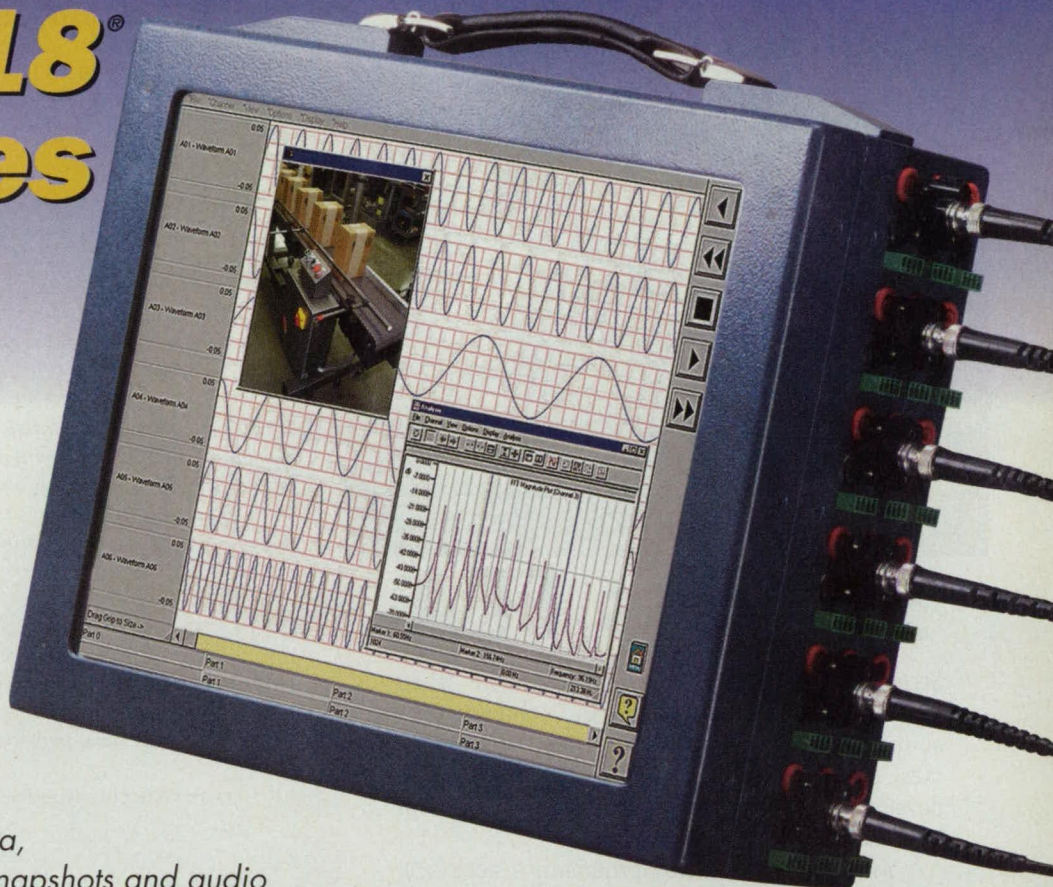
**Inventors:** Daniel B. Leiser, Ming-ta Hsu, and Timothy S. Chen, Ames Research Center

Low-density insulations are required to thermally protect the structure of the Space Shuttle from the high temperatures normally encountered during atmospheric entry. A characteristic of a successful insulation is high thermal shock resistance. The temperature limitations of current materials and the desirability of improving their mechanical properties are reasons for developing alternative materials. The invention relates to lightweight, high-temperature ceramic insulation, that is, a carbon tile combining carbon, silicon, and oxygen derived from the reaction of an organodialkoxysilane and an organotrialkoxysilane to form a sol-gel in the presence of a porous carbon substrate. This tile would be able to retain its shape and strength when exposed to an oxidizing environment at temperatures in excess of 1200 degrees Celsius. The method of this invention starts by coating or impregnating a porous carbon substrate with the reaction product to form a gel *in situ*, or in the presence of the porous carbon substrate, followed by drying the substrate and subsequently heating or pyrolyzing it, in an inert atmosphere, to form the ceramic carbon insulation.

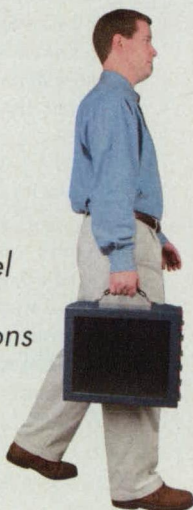
*For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. See page 24 for a list of office contacts.*



# What do you need to record? Waveforms – Video – Audio... **Dash 18<sup>®</sup>** handles it all!

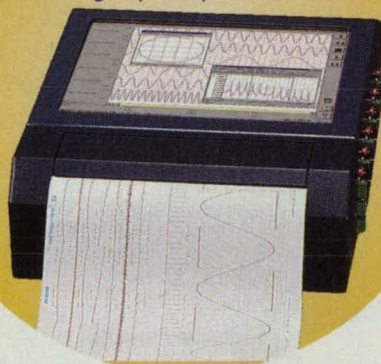


- Record waveform data, synchronized video snapshots and audio
- 18 Universal input channels for voltage, thermocouple and bridge
- 15.4" touch-screen display for data viewing and analysis
- Record data directly to 9 GB hard drive at 100 kHz per channel
- Real-time filtering and math functions
- 10/100 BaseT Ethernet interface and 250 MB Zip drive



## Optional Printer

For real-time recording or playback from memory, an attachable 10" wide high speed printer is available.



Call, E-mail, Fax, or write to us today for all the details. Web Site: [www.astro-med.com/de111](http://www.astro-med.com/de111)



**Astro-Med, Inc.**  
TEST & MEASUREMENT PRODUCT GROUP

**Astro-Med is System Certified to ISO-9001**

Astro-Med Industrial Park, West Warwick, Rhode Island 02893  
Phone: (401) 828-4000 • Toll Free: 1-877-867-9783 • Fax: (401) 822-2430  
In Canada Telephone 1-800-565-2216 • E-mail: [mtgroup@astromed.com](mailto:mtgroup@astromed.com)





## Serious FEA

Structural failure is simply unacceptable when you're pulling 8G's at 600 mph. Or Depending on a spinal implant. Or an automotive fuel tank. Or the mast of an America's Cup contender. This is why developers of the most critical structures depend on **NE/Nastran** for FEA analysis.

Along with uncompromising accuracy, **NE/Nastran** is one of the most complete, easiest-to-learn-and-use FEA packages available. And it's yours for 1/3 to 1/10 the price of comparable software.

**Free Demo.** We're so sure that you'll see the value in **NE/Nastran** that we want you to use a demo version for free.

It runs on Windows 95/98/NT4.0/2000 with Unix and Linux versions available soon. Visit our web site to learn more about this serious FEA, and download your free evaluation copy.



Upgraded F-5E fighter avionics bay, radar support structure, and wing analyzed using **NE/Nastran**.



**Noran Engineering, Inc.**  
www.NENastran.com  
Toll Free: 877-NENastran

© 2001, Noran Engineering, Inc. NE, NE/ and NEI logo are registered trademarks of Noran Engineering, Inc. NASTRAN is a registered trademark of the National Aeronautics and Space Administration. Windows is a registered trademark of Microsoft Corporation.

**For Free Info Circle No. 404 or Enter No. 404 at**  
**www.nasatech.com/rs**

## Reader Forum

Reader Forum is dedicated to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a technical problem, or an answer to a previously published question, post your letter to Reader Forum on-line at [www.nasatech.com](http://www.nasatech.com), or send to: Editor, *NASA Tech Briefs*, 317 Madison Ave., New York, NY 10017; Fax: 212-986-7864. Please include your name, company (if applicable), address, and e-mail address or phone number.

**I** am looking to purchase Nafion membrane N-117. Does anyone know where I can obtain this? Any information is greatly appreciated.

Ping Liu  
pingliu2001@yahoo.com

*(Editor's Note: Ping, Nafion is a DuPont resin that is available in membrane form. The non-reinforced films, or membranes, are based on Nafion, which is a perfluorosulfonic acid/PTFE copolymer in the acid form. Visit the DuPont Web site at: [www.dupont.com](http://www.dupont.com), or contact the Nafion Tech Service center at 800-436-1336.)*

Where can I find information on the benefits that have been realized from advances in space technology, and the conveniences that they have provided?

tapley@accucomm.net

*(Editor's Note: Many Americans are unaware of the technologies and products we use every day that trace their origins to the space program and to NASA development. NASA produces an annual publication called Spinoff that features stories on the successful transfer and application of NASA-generated technology, and how that technology is applied to new commercial products. Go to [www.nasatech.com/spinoff](http://www.nasatech.com/spinoff), and you can view and download current and recent issues of Spinoff.)*

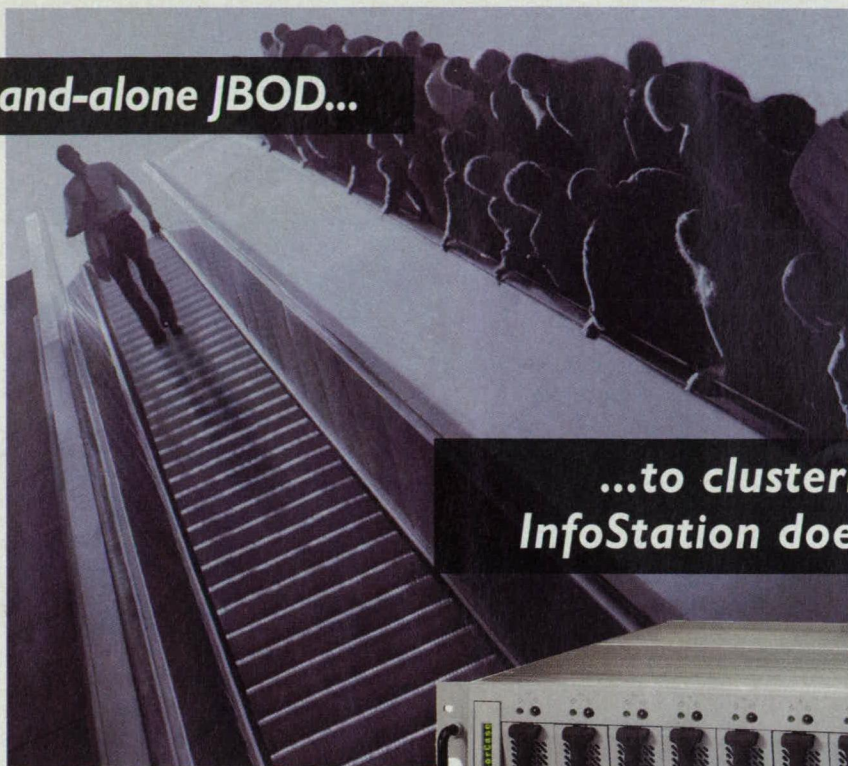
There was a tech brief in a past issue of *NASA Tech Briefs* that described Delta-Doped Hybrid Advanced Detectors (October 1998). I would like to evaluate these detectors for a charged particle instrument application. I'd like to know if these devices have been successfully produced, and if the units are available for evaluation.

Walter Lockhart  
wlockhart@coolohms.com

*(Editor's Note: Walter, the work was performed by a team from Caltech for NASA's Jet Propulsion Laboratory (JPL) in Pasadena, CA. You can get further information on the invention and its licensing from the Intellectual Property group at JPL; Tel: 818-354-2240. Refer to the tech brief number NPO-20111 and the issue in which it appeared.)*



**From a stand-alone JBOD...**



**...to clustering,  
InfoStation does it all.**

**"Wow, talk about an  
enclosure with great ROI!"**



**WITH STORAGE REQUIREMENTS GROWING AT SUCH A RAPID PACE,** StorCase recognizes that a large part of a company's IT budget may be spent on storage, making Return On Investment (ROI) more critical than ever before. Today, savvy IT Managers look for storage solutions that are scalable, field-upgradable and flexible enough to grow and change with their future storage needs.

StorCase has responded to these important issues with InfoStation™, their intelligent 9-bay backplane enclosure that is ready for the future.

Call a StorCase Product Specialist today at (800) 337-8421. Order a rack or tower evaluation unit and experience all the unique features listed below for yourself.

#### **UNIQUE INFOSTATION FEATURES:**

- Configurable "4 channel-ready" backplane. Order a pre-configured model, available with 1, 2 or 4 channels, or begin with one channel and add field-upgradable channels as needed.
- Enhanced repeater interface technology allows users to build a mission critical storage cluster without experiencing performance degradation or loss of throughput.
- Since StorCase RAID Controller Modules are plug-and-play options, they can be purchased with InfoStation, or added later, allowing the user to easily upgrade from a JBOD to an enterprise storage solution at any time.
- A FREE Web-based storage management utility, InfoMon™, allows users to monitor InfoStation's vital signs on demand.
- Just (1) StorCase Fibre-to-SCSI RAID Controller Module supports up to (8) InfoStations and (60) drives and/or up to 10.8 TB of storage! SCSI-to-SCSI RAID Controller Modules are also available.
- InfoStation is platform-independent, allowing easy connection to a user's current server, array or storage network, without compatibility concerns.

[www.storcase.com](http://www.storcase.com)

 **StorCase**  
TECHNOLOGY  
A Kingston Technology Company

INGRAM  
MICRO

D&H

GATES/ARROW  
DISTRIBUTING

AVNET  
COMPUTER

Tech Data

SYNNEX

BELL MICROPRODUCTS

CONSAN  
A GATES/ARROW Company



©2001 StorCase Technology, Inc. A Kingston Technology Company. 17600 Newhope Street, Fountain Valley, CA 92708, USA (714) 438-1850, Fax (714) 438-1847.  
All trademarks and registered trademarks are the property of their respective owners.



# Technologies of the Month

Sponsored by **yet2.com**

For more information on these and other new, licensable inventions, visit  
[www.nasatech.com/techsearch](http://www.nasatech.com/techsearch)

## Quick Chilling Technology Holds Promise for Diverse Uses

*Carol Kralicek, Enersyst*

Based on convection currents, a new chilling and thawing technology chills food up to 15 times faster and thaws foods up to three times faster than conventional chilling technologies. Using jets of air directed at the surface of the item to be cooled, it rapidly and evenly changes the temperature of the food by disturbing the layer of stagnant air next to the surface. Called "air impingent cooling," this technology directs or "impinges" jets of air perpendicularly against a product's surface at a rate of several thousand feet per minute. This action creates high- and low-pressure areas that assist in the movement of the air, accelerating the cooling.



This technology can be retrofitted to existing refrigeration units or can operate as a standalone cooling system, chilling and thawing food and beverages as needed. Applications include the food manufacturing and service industries, as well as metallurgy, HVAC, and laboratory processes that require rapid cooling.

Get the complete report on this technology at:  
[www.nasatech.com/techsearch/tow/enersyst.html](http://www.nasatech.com/techsearch/tow/enersyst.html)

## A Unique Way to Produce Ultra Low Sulfur Diesel (ULSD)

*Dr. W.S. Min, SK Corporation, Taejon R&D Center*

Many governments have restricted the amounts of contaminants, sulfur, NOX, particulates, and/or aromatics and olefins a petroleum-based fuel may have in order to assure a cleaner atmosphere when these fuels are burned for energy. Hydro-desulfurization, a hydrogen treating process, has been the prime method of contaminant removal, but it requires high levels of pressure and temperature. And nitrogen compounds in the diesel feedstock inhibit the catalytic reactions needed to remove contaminants.

The new technique is an adsorption type process that removes about 90% of undesirable nitrogen compounds from the diesel feedstock that would normally go directly to a hydro-desulfurization unit for sulfur removal. The absorbers are liquid-filled at all times, and can last for at least one year. Common solvents are used, and the final diesel product has lower amounts of sulfur, a lighter color, and better storage stability.

Get the complete report on this technology at:  
[www.nasatech.com/techsearch/tow/sk.html](http://www.nasatech.com/techsearch/tow/sk.html)

## Rotating Device Performs as Seal, Bearing, or Pump

*Douglas T. Bridge, Principal Engineer, Advanced Technology Development, A.W. Chesterton*

This new rotating device is based on Taper Spiral Groove (TSG) technology, a tapered, grooved rotor that uses spiral grooves to create a concentric film between the stator and the rotor that can be adjusted for thickness and flow. When used as a bearing, the device replaces bulky, radial and axial bearings with their larger housings and support systems. As a pump, the device provides high-pressure, low-flow performance that can be used to hydraulically load other devices, such as lubricating systems. As a wind-back seal or visco seal, it prevents liquids from leaking along rotating shafts.

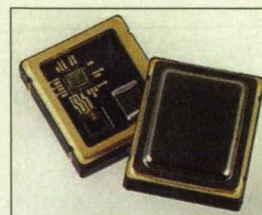
TSG technology reduces equipment vibration and wear, and can be used for pumps, gear boxes, turbines, compressors, and other rotating equipment in process industries such as pulp and paper, pharmaceuticals, and chemical manufacture. It also has applications in utilities, transportation and heavy equipment, marine systems, and agriculture.

Get the complete report on this technology at:  
[www.nasatech.com/techsearch/tow/chesterton.html](http://www.nasatech.com/techsearch/tow/chesterton.html)

## New Sensors Adaptable to a Range of Applications

*Toshihide Kuriyama, NEC*

Two new sensors are showing potential for transportation and communication applications. The first is a semiconductor-based acceleration sensor that uses silicon etching methods to create a smaller base in the middle of the chip, thus increasing stability. They are ideal for detecting vehicle speed to assist safety and suspension systems. Acceleration data

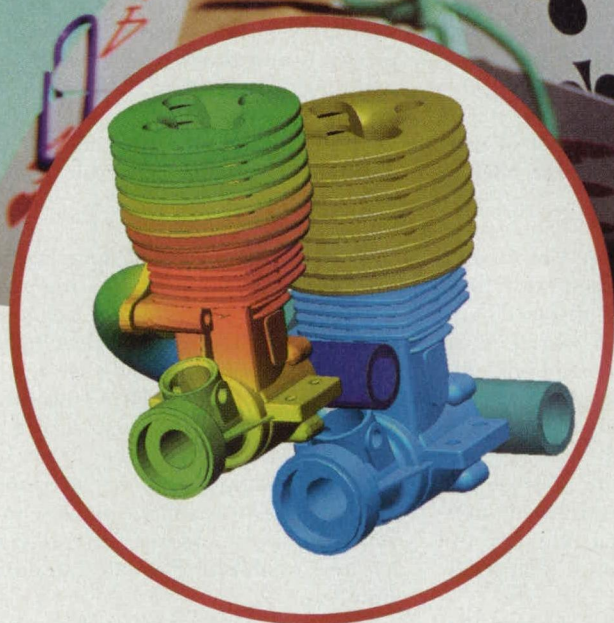


from the sensors can be used to determine velocity and position for guidance, navigation, and positioning applications in industries such as avionics, automotive, robotics, GPS, defense, and civil engineering.

The second sensor can replace the PC mouse with a stationary device that features two finger sockets that contain a series of capacitance sensors to track finger movement within the socket space. These sensors enable precise positioning of a cursor on a computer screen making it ideal for applications requiring cursor-based interactivity, such as virtual reality, navigation systems, personal digital assistants, and computer-aided design and manufacturing systems.

Get the complete report on this technology at:  
[www.nasatech.com/techsearch/tow/nec.html](http://www.nasatech.com/techsearch/tow/nec.html)





## Are you Sure You have A Good Design?

Will it overheat? Will the stresses be too high? Will it break? If you are designing your models without using analysis, you could be risking a potential part failure - without even realizing it.

Don't take unnecessary chances with your design. Use COSMOS/<sup>TM</sup> throughout the design cycle to help identify potential problems before it's too late.

**COSMOS/WORKS**  
**COSMOS/DESIGNSTAR**

With COSMOS/, engineers are building better, more cost efficient products while taking weeks, even months off of the design cycle.

COSMOS/ tackles even the most complex design tasks, while being intuitive enough for any engineer to quickly learn and use, regardless of previous experience.

For information on how COSMOS/ can help you work smarter instead of harder and a **FREE** 15-day trial, call us today at **1-800-469-7287** or visit us online at <http://nasa.cosmosm.com>.



**Fast.  
Reliable.  
Safe.  
Everything  
automated  
riveting  
should be.**



### **Introducing POPmatic Point & Set™, the first reliable auto-feed rivet system.**

POPmatic Point & Set, our new auto-feed rivet system, delivers what no riveting tool has before. Consistent riveting at a rate faster than any current hand tool. Designed with a safe, self loading hopper that holds up to 2500 rivets, Point & Set accelerates the riveting process to previously impossible speeds, meeting the requirements of any production line. It's reliability in an otherwise unreliable world. For more information, call us at 203-925-4424 or visit us on the web at [www.emhart.com](http://www.emhart.com)

**Emhart®**  
**POPMATIC**

A BLACK & DECKER COMPANY

CERTIFIED  
ISO 9001 • QS 9000

## **Dr. Yoseph Bar-Cohen, Senior Research Scientist, Nondestructive Evaluation (NDE) Group, Jet Propulsion Laboratory**

**D**r. Bar-Cohen is a physicist specializing in ultrasonic NDE and electroactive materials and mechanisms at NASA's Jet Propulsion Laboratory in Pasadena, CA. He established the Nondestructive Evaluation and Advance Actuators (NDEAA) Lab in 1991. Currently, he is developing electroactive polymer actuators — artificial muscles — and an ultrasonic drill.



**NASA Tech Briefs: What types of technologies are developed at the NDEAA Lab?**

**Dr. Yoseph Bar-Cohen:** The focus is on phenomena associated with time-dependent mechanical displacements in the form of waves or vibrations induced by electroactive materials. We are seeking planetary applications and potential spinoffs to aerospace, medical, and commercial areas. Currently, we are developing the Ultrasonic/Sonic Drill/Corer, electroactive polymers (EAP) as artificial muscles, and medical treatment and diagnostic methods.

Some of the unique devices that we've developed include a dust wiper and a gripper that excited the imagination of many with regards to the potential of EAP materials. In the high-frequency and high-power domain, we are exploring medical treatment methodologies jointly with the UCLA Medical Center.

**NTB: Have any of these innovations been spun-off by NASA for commercial use?**

**Dr. Bar-Cohen:** We are continually seeking avenues to commercialize our technologies, both through our own initiatives and in response to inquiries. The ultrasonic drill, which we are developing jointly with Cybersonics, is already being produced commercially by our partner. This drill is capable of

drilling with low power and low pressure on the bit, drilling rocks as hard as basalt and granite. It does not require sharpening and it extracts the produced powder via an ultrasonic transport mechanism up the drilling bit. We also developed an ultrasonic rock abrasion tool (URAT) as a backup device to the Mars 2003 mission. We also have other technologies with great potential, including our piezopump that potentially can be used as a beeper-sized peristaltic system to inject multiple types and doses of medications in real time.

**NTB: You're also working on the MEMICA program. Can you tell us about that?**

**Dr. Bar-Cohen:** It is a haptic system of remote MEchanical MIrroring using Controlled stiffness and Actuators (MEMICA) that we are developing jointly with Prof. Mavroidis from Rutgers University. MEMICA was conceived to provide teleoperators with an intuitive feel of objects that are being remotely manipulated. It will potentially augment astronaut activity, providing countermeasures for zero-gravity, and establishing medical training simulators.

MEMICA offers potential applications both as a telepresence system using a surrogate robot, or virtual reality. This technology is expected to have many spinoffs, including medical, military, sports, training, and entertainment. For space, we are envisioning applications such as remote operation of robots, where it could maneuver through areas too small for the current Space Station robots. It also can be used for simulated medical procedures, providing the capability to train or remotely guide a medical staff. With the aid of all-in-one type surgical tools, astronauts with medical backgrounds would be able to perform urgent care procedures as they develop.

*A full transcript of this interview appears on-line at [www.nasatech.com/whoswho](http://www.nasatech.com/whoswho). Dr. Bar-Cohen can be reached at [yosi@jpl.nasa.gov](mailto:yosi@jpl.nasa.gov).*






IF YOU CAN THINK IT, WE CAN DO IT.

Emhart is a world leader in the design and supply of innovative fastening and assembly technology. From concept through installation, whether you're manufacturing around the corner or around the globe, Emhart provides cost-effective solutions for assembly applications. Visit us at [www.emhart.com](http://www.emhart.com)

**Emhart**<sup>®</sup>

A  BLACK & DECKER COMPANY



NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (609) 667-7737 for the FLC coordinator in your area.

## NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

### Ames Research Center

Selected technological strengths: Information Technology; Biotechnology; Nanotechnology; Aerospace Operations Systems; Rotorcraft; Thermal Protection Systems.  
*Carolina Blake*  
(650) 604-1754  
*cblake@mail.arc.nasa.gov*

### Dryden Flight Research Center

Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.  
*Jenny Baer-Riedhart*  
(661) 276-3689  
*jenny.baer-riedhart@dfrc.nasa.gov*

### Goddard Space Flight Center

Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Remote Sensing; Command.  
*George Alcorn*  
(301) 286-5810  
*galcorn@gsc.nasa.gov*

### Jet Propulsion Laboratory

Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.  
*Merle McKenzie*  
(818) 354-2577  
*merle.mckenzie@jpl.nasa.gov*

### Johnson Space Center

Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.  
*Charlene E. Gilbert*  
(281) 483-3809  
*commercialization@jsc.nasa.gov*

### Kennedy Space Center

Selected technological strengths: Fluids and Fluid Systems; Materials Evaluation; Process Engineering; Command, Control and Monitor Systems; Range Systems; Environmental Engineering and Management.  
*Jim Aliberti*  
(321) 867-6224  
*Jim.Aliberti-1@ksc.nasa.gov*

### Langley Research Center

Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.  
*Sam Morello*  
(757) 864-6005  
*s.a.morello@larc.nasa.gov*

### John H. Glenn Research Center at Lewis Field

Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.  
*Larry Viterna*  
(216) 433-3484  
*cto@grc.nasa.gov*

### Marshall Space Flight Center

Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.  
*Vernotto McMillan*  
(256) 544-2615  
*vernotto.mcmillan@msfc.nasa.gov*

### Stennis Space Center

Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.  
*Kirk Sharp*  
(228) 688-1929  
*kirk.sharp@ssc.nasa.gov*

## NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

**Carl Ray**  
**Small Business Innovation Research Program (SBIR) & Small Business Technology Transfer Program (STTR)**  
(202) 358-4652  
*cray@mail.hq.nasa.gov*

**Dr. Robert Norwood**  
**Office of Commercial Technology (Code RW)**  
(202) 358-2320  
*norwood@mail.hq.nasa.gov*

**John Mankins**  
**Office of Space Flight (Code MP)**  
(202) 358-4659  
*jmankins@mail.hq.nasa.gov*

**Terry Hertz**  
**Office of Aero-Space Technology (Code RS)**  
(202) 358-4636  
*thertz@mail.hq.nasa.gov*

**Glen Mucklow**  
**Office of Space Sciences (Code SM)**  
(202) 358-2235  
*gmucklow@mail.hq.nasa.gov*

**Roger Crouch**  
**Office of Microgravity Science Applications (Code U)**  
(202) 358-0689  
*rcrouch@hq.nasa.gov*

**Granville Paules**  
**Office of Mission to Planet Earth (Code Y)**  
(202) 358-0706  
*gpaules@mtpe.hq.nasa.gov*

## NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

**Wayne P. Zeman**  
**Lewis Incubator for Technology**  
Cleveland, OH  
(216) 586-3888

**Thomas G. Rainey**  
**NASA KSC Business Incubation Center**  
Titusville, FL  
(407) 383-5200

**B. Greg Hinkebein**  
**Mississippi Enterprise for Technology**  
Stennis Space Center, MS  
(800) 746-4699

**Joanne W. Randolph**  
**BizTech**  
Huntsville, AL  
(256) 704-6000

**Julie Holland**  
**NASA Commercialization Center**  
Pomona, CA  
(909) 869-4477

**Joe Becker**  
**Ames Technology Commercialization Center**  
San Jose, CA  
(408) 557-6700

**Bridgette Smalley**  
**UH-NASA Technology Commercialization Incubator**  
Houston, TX  
(713) 743-9155

**Marty Kaszubowski**  
**Hampton Roads Technology Incubator (Langley Research Center)**  
Hampton, VA  
(757) 865-2140

**John Fini**  
**Goddard Space Flight Center Incubator**  
Baltimore, MD  
(410) 327-9150 x1034

## NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

**Joseph Allen**  
**National Technology Transfer Center**  
(800) 678-6882

**Dr. William Gasko**  
**Center for Technology Commercialization**  
Massachusetts Technology Park  
(508) 870-0042

**Gary Sera**  
**Mid-Continent Technology Transfer Center**  
Texas A&M University  
(409) 845-8762

**Pierrette Woodford**  
**Great Lakes Industrial Technology Transfer Center**  
Battelle Memorial Institute  
(216) 898-6400

**Ken Dozier**  
**Far-West Technology Transfer Center**  
University of Southern California  
(213) 743-2353

**B. David Bridges**  
**Southeast Technology Transfer Center**  
Georgia Institute of Technology  
(404) 894-6786

**Charles Blankenship**  
**Technology Commercialization Center**  
Newport News, VA  
(757) 269-0025

**NASA ON-LINE:** Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at <http://nctn.hq.nasa.gov> to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center**, (505) 277-3622.



# Ease of Use is Key for Analysis Software Vendors

**M**aking the design process better — that's the focus of both CAD and analysis software tools. Increasingly, these two areas of engineering software are moving closer together to provide users with what they've been demanding — the ability to work the way they want to.

Analysis and simulation tools are introduced into the product development process when the first conceptual design and engineering work begins, according to Jim Tung, chief market development officer for The MathWorks, which provides MATLAB and Simulink analysis tools. "Whatever is being created — whether it's a cell phone, an airplane, or a car — at the end of the day, it's going to be a multi-domain, multi-disciplinary problem" requiring both CAD and analysis. Preserving this hand-in-hand relationship means that the CAD and analysis products must take advantage of each other's capabilities. "CAD packages have become more widely used in the design process, so there are many benefits if an analytical tool can leverage the modeling power within those CAD pack-

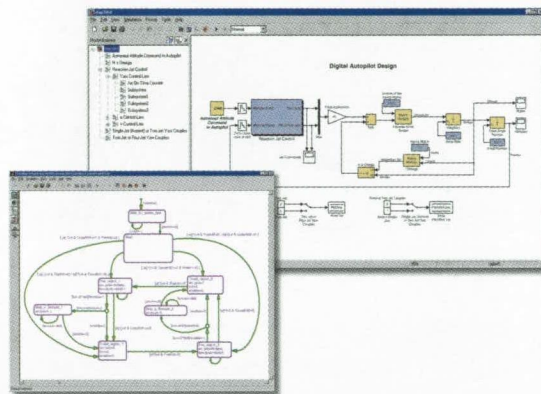
ages," said Bob Williams, product manager for ALGOR, Inc., a provider of finite element analysis (FEA) tools.

CAD is often thought of as the design tool, and analysis as the verification tool. "In the physical world, you build something and test it," said Ken Blakely, vice president of MSC Software, a provider of analysis and simulation software. "If it doesn't work, you re-do it. Today, you design something in CAD and you do the design verification using analysis."

Analysis and simulation packages also are becoming easier to use, making the distinction between a CAD operator or designer and an engineer or analyst much more blurred. "We work with SolidWorks, Solid Edge, Mechanical Desktop, Inventor, CADKEY, and Pro/ENGINEER," said Williams. "There are certain ways of operating within each of these modeling programs. Analysis software providers must offer tools that allow users from each of these different CAD and engineering backgrounds to be able to efficiently leverage analytical tools."

Various levels of education and training come into play when discussing ease of use. Analysis and simulation software has long been considered the domain of engineers. That is changing. Suchit Jain, vice president of marketing for Structural Research & Analysis Corp. (SRAC), maker of the COS-

MOS line of analysis products, believes that analysis software is definitely becoming easier to use. "Sixty to 70 percent of the time when you're designing in CAD and you need to check perfor-



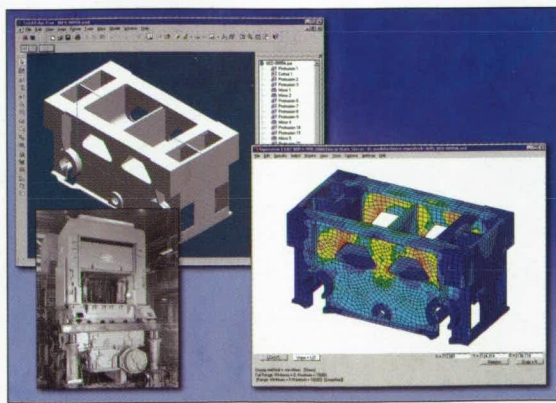
Simulink and Stateflow from The MathWorks provide model-based design, analysis, and simulation capabilities, with interfaces to domain-specific modeling and CAD packages.

mance, you're looking for a very limited functionality within an FEA product. The need most of the time is for a very specific scenario. It's like when you buy a TV. You think, 'I may not use all 100 channels,' but it's good to have them."

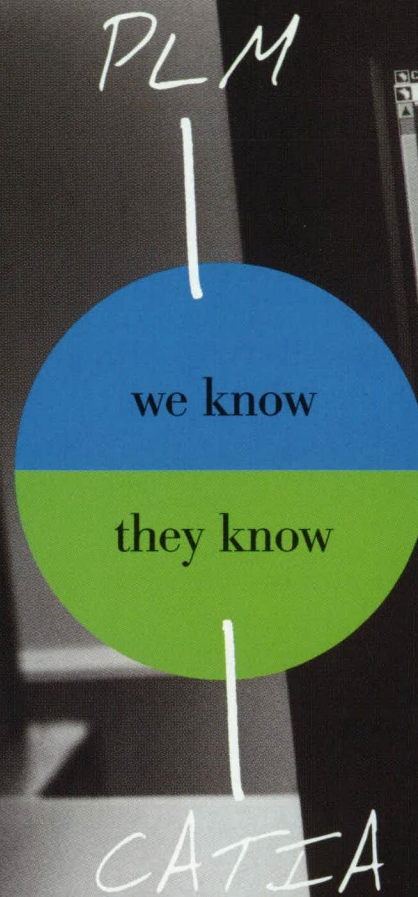
A significant learning curve still exists for mastering analysis software, but Tung believes that may be misleading. "CAD programs are easy to get into, but it takes a long time to become a master user." The difference, he explained, is ease of introduction. "A CAD tool has a learning curve that's very gradual, but it goes up rather steeply. Analysis tools have a curve that's steeper at the beginning, but it will drop off. Once you've mastered the fundamentals of analysis tools, it's easier to do a lot of different things."

## Does Collaborative Analysis Exist?

CAD vendors have taken advantage of the Internet in a big way, incorporating



Danly Engineering Services, a division of Enprotech Mechanical Services, analyzed a modification to a power press located at a General Motors plant to accommodate a different die. Engineers built the modified geometry in Solid Edge and used ALGOR's fully associative InCAD technology to capture the model and perform a finite element analysis.



CATIA: driving innovation, this advanced 3D design links design and manufacturing, improves collaboration. Along with IBM's industry expertise, it's part of a comp

IBM

@business



## CATIA AND INNOVATION

CATIA®, the world's leading CAD/CAM/CAE software, takes 3D design and innovation to a new level. It streamlines the entire development process from idea to design and through the entire product life cycle by providing a virtual environment for testing, prototyping and manufacturing. It drives the development of innovative, high-quality products, while drastically reducing time for development, cutting costs and providing a faster return on investment.

Better still, it opens up a new range of market opportunities by offering not only the ability to customize on a massive scale, but also personalization for every customer. In short, it gives you the power to create innovative products in a market where innovators lead. And ultimately win.

## PLM AND COLLABORATION

IBM's Product Lifecycle Management (PLM) solutions provide an integrated approach to the development of products that fosters innovation. How? By linking your product team's knowledge and processes with the network of suppliers, engineers, customers and partners on which your success ultimately depends. CATIA is an integral part of IBM's PLM solutions.

## SEE FOR YOURSELF

The trial code CD version of the latest, award-winning CATIA software is yours to try, free, for 30 days. Simply call 1 800 IBM 7777 (Priority Code 6N1FS030) or visit our Website: [ibm.com/solutions/catia](http://ibm.com/solutions/catia)



COLLABORATION

we know

they know

INNOVATION

**CATIA:** driving innovation, this advanced 3D design and engineering software from Dassault Systemes links design and manufacturing, improves collaboration, reduces costs and gets products to market faster. Along with IBM's industry expertise, it's part of a complete PLM solution. See it at [ibm.com/solutions/catia](http://ibm.com/solutions/catia)



IBM and the e-business logo are trademarks and registered trademarks of International Business Machines Corporation in the U.S. and other countries or both. CATIA is a registered trademark of Dassault Systemes S.A. ©2001 IBM Corporation. All rights reserved.



collaborative capabilities that enable users to share and interact with each other's models and related data. While the need for collaboration exists in the analysis and simulation area, many view analysis software as a more individually oriented product.

Research Systems is an Eastman Kodak company that produces IDL® data analysis and visualization software that is used by customers such as NASA for image analysis. Richard Cooke, vice president of engineering for Research Systems, explained that his company spends a significant amount of time looking at architecture in terms of how it plays into the Internet world. "Collaboration is one key. NASA, for example, doesn't just want to serve up image data," said Cooke. "They want certain pieces of our analysis tools available to the person looking at the image on the Internet, so he or she can manipulate the image. Everything we do in the scientific and engineering world eventually will need to be shared and collaborated on over the Internet."



This 3D visualization of charge density is displayed in IDL software from Research Systems. The data was provided by Lloyd Treinish of Lawrence Livermore National Lab.

The Internet hasn't taken off as a collaboration tool for analysis software users for a number of reasons, said SRAC's Jain. "For high-end FEA products, the software takes a long time to run, and FEA usually produces a lot of data that may be proprietary," Jain does see an even broader use, however. "We know that using the Internet as a computing platform is something that will be present in the future. People will start using Microsoft. NET as a popular platform," Jain predicted.

MSC's Blakely believes that the Internet has not had a huge impact on the analysis software market yet, but that a change is coming. "What I do expect to see over the next few years is people using the Internet to pull together models that have been analyzed in different places." MSC and other vendors continue to expand their use of the Internet more as a communications and

training tool than an interactive collaboration tool.

"The Internet has allowed a wider use of technology to help end users of products learn how to use those products, stay up to date on what's available for that product, and continue to leverage new capabilities," said ALGOR's Williams. "As a piece of the whole puzzle, there definitely is a need for collaboration within analysis," he explained. "It won't be as interactive a collaboration, but you can keep data coupled together so if someone makes a change, the others will know about it. After run-

ning an analysis, reporting and presentation tools allow you to publish the results to a Web site so others can benefit from the knowledge gained from the analysis."

### Computing Power and Other Trends

Software vendors are taking a closer look at their users' computing power and platforms to plan for future demands. According to Tung, The MathWorks sees a trend towards the number of users doing analysis work on Windows-based machines. "I don't think UNIX will go away," Tung said. "Devel-

## HIGH FLOW pressure control to 30,000<sup>1</sup> scfm!

- Inlet pressures up to 6,000 PSIG
- Control pressure ranges of 1-6,000 PSIG
- Heavy duty construction - choice of brass or 316 SST
- Modular construction style allows easy servicing
- Inlet and outlet port sizes to 1 1/4"
- SAE, NPT or MS 33649 ports are standard
- Welded flanges available

**TESCOM**  
CORPORATION  
1-800-447-1250  
[www.tescom.com](http://www.tescom.com)



Global support & distribution • Design/manufacture in the US, Germany & Asia

<sup>1</sup> with 6,000 PSIG inlet, 3,000 PSIG outlet,  $C_v=12$ , media:  $N_2$



opment and design teams will have to be multi-environment. An individual user may work only on Windows or UNIX, but they need to share their ideas across platforms."

As PC computing power increases, there will be less of a comparison between how analysis is run on UNIX and PCs. What ALGOR is focusing on, according to Williams, is the PC chip. "Many of them are beginning to have special instruction sets to allow math operations to occur more quickly. We also are looking at the ability to leverage multiple processors on the PC," Williams said.

Most vendors agree that there is — and must continue to be — an even more important trend in the analysis software arena: ease of use. Computing power, collaborative capabilities, and close communication with the CAD vendors are all important, but the bottom line is making the software easier to use, improving engineers' productivity.

Cooke recognizes that Research Systems, like other vendors, needs to focus more on ease of use. "IDL is a very robust analysis tool, but it does require some level of programming skill. We believe we'll have to broaden the market

by extracting that programming layer even more."

Whether it's a designer or an engineer who's operating the software, productivity needs to be the main concern. The engineers and designers who perform the analysis have to spend much of their time obtaining the right inputs and verifying them, said MSC's Blakely. "They spend more time on that than doing the analysis itself. Engineers, in many cases, have become expensive bookkeepers," he added. "We need to change that and free up more of the engineers' time, so

they can become innovators and truly add value to a company's product."

The best way to ensure that productivity is to let engineers work the way they want to work, according to ALGOR's Williams. "We want engineers to be able to model parts in CAD packages, analyze those parts in packages that have the robust capabilities to perform those analyses, and have them all work together very well."

Visit [www.nasatech.com/features](http://www.nasatech.com/features) for more comments from industry leaders on the analysis software market.

## Get Connected to the Companies Featured in this Article:

ALGOR, Inc. .... [www.algor.com](http://www.algor.com)

The MathWorks ..... [www.mathworks.com](http://www.mathworks.com)

MSC Software ..... [www.mscsoftware.com](http://www.mscsoftware.com)

Research Systems ..... [www.researchsystems.com](http://www.researchsystems.com)

Structural Research & Analysis Corp. .... [www.srac.com](http://www.srac.com)

## the **WAVE** you've been waiting for...

Introducing **PV-WAVE® 7.5** with more features to help you solve complex problems. PV-WAVE is an easy-to-use analysis and visualization environment that enables engineers, scientists, researchers and business analysts to understand complex data sets and rapidly build visual data analysis applications.

PV-WAVE 7.5 strengths include:

- A Visualization Toolkit (VTK) approach that offers a high-level, easy-to-use interface to OpenGL.
- High-quality, reliable analysis through the integration of the Visual Numerics' IMSL® C Numerical Library.
- Efficient memory utilization, critical to working with large data sets.

Discover what customers worldwide have known for 30 years. Visual Numerics' PV-WAVE can increase productivity, accelerate development and illustrate key knowledge contained in your data.



Read real-life **PV-WAVE** success stories and find out more about the new version at:

[www.vni.com/easy](http://www.vni.com/easy)

PV-WAVE - HELPING CUSTOMERS **SOLVE** COMPLEX PROBLEMS

© 2001 Visual Numerics, Inc. Visual Numerics, PV-WAVE & IMSL are registered trademarks of Visual Numerics, Inc.

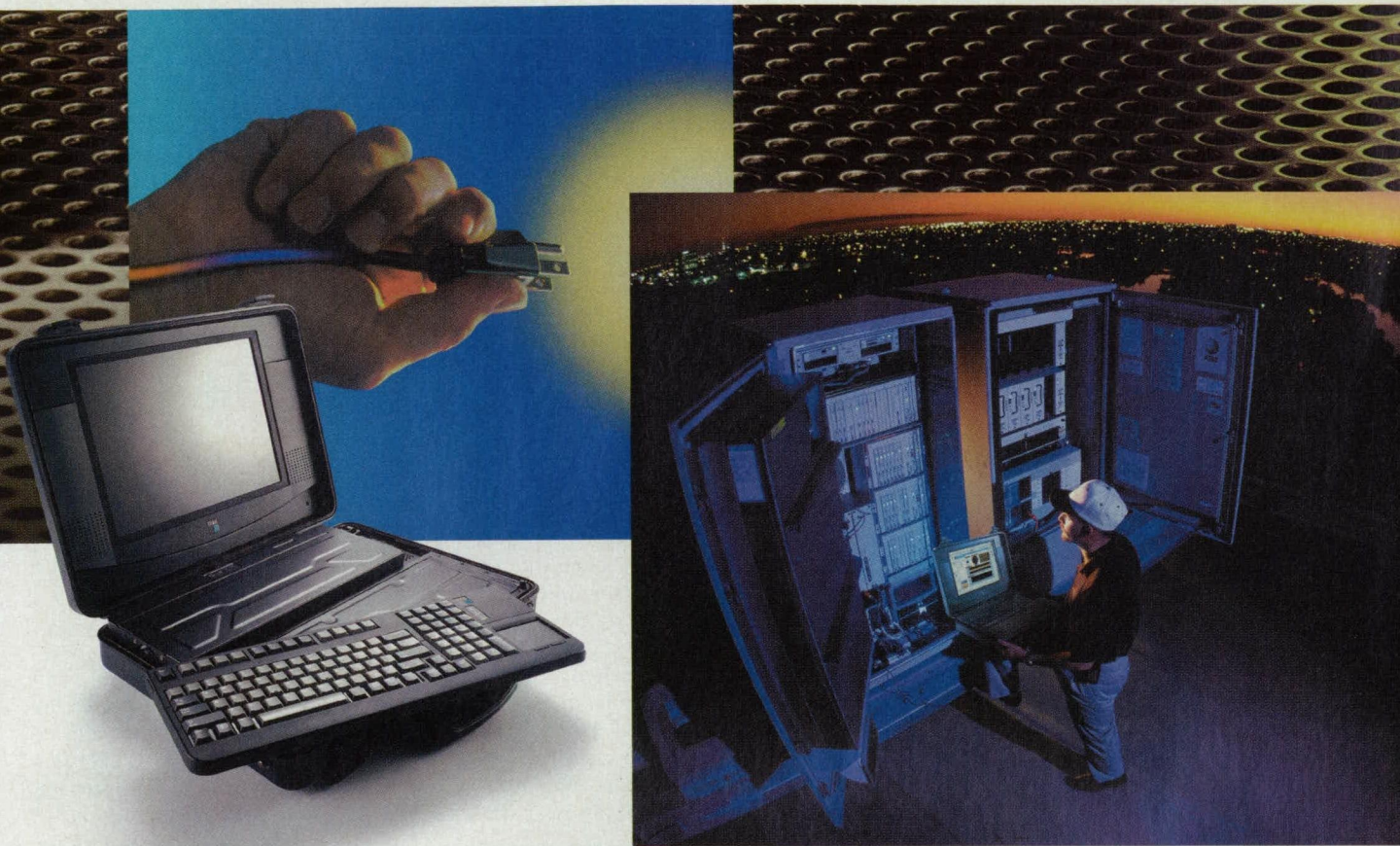
"Visual Numerics has partnered with us by providing not only the best technology, but also service that is unparalleled in the industry!"

Brian Young  
Senior software engineer  
Marquette Medical Systems

**PV-WAVE® 7.5**  
Visual Numerics



# You can pull the plug...



## ...but you can't kill the power.

**Introducing the world's first ruggedized portable with a six hour battery life.**

Tired of not having access to power where and when you need it? Those days are history thanks to the all-new Dolch FieldPAC,<sup>™</sup> the only ruggedized portable with a six hour battery life. Imagine taking your desktop right into the field and never having to worry about finding a power source again. Want more? How about a CD read/write drive, USB port, audio, Ethernet, removable hard drive, and a full-size keyboard. Plus all the durability and quality you expect from Dolch. All backed by the Dolch Difference,<sup>™</sup> the most comprehensive customer support initiative in the industry. So no matter what type of environment you work in—more power to you!

For more information, check out [www.BatteryPAC.com](http://www.BatteryPAC.com) or call 877.347.4924.





# MSC's "Clean" Meshing Solution

Steven S. Ross

If you routinely try to run finite element analysis (FEA) on very large models (1,000 faces or more), you know one of the biggest bottlenecks — minor defects in the CAD file of the model itself can make mesh generation impossible. You go back and forth between the meshing engine and the CAD software, trying to get all your model elements aligned correctly. Also, translating from the model into something the meshing engine understands can mean lost detail.

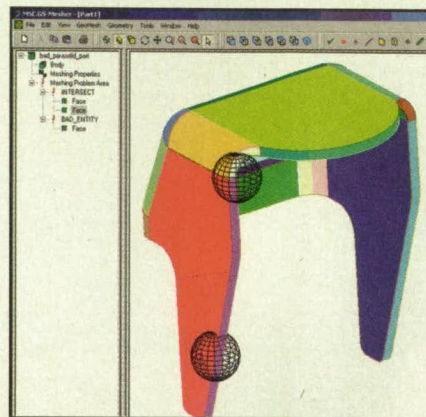
MSC Software has come up with a nifty solution — a solid and surface meshing engine called GS-Mesher 1.1 that works directly on CAD files with no translation step, so that the files can be cleaned quickly and meshes modified without having to go back to the CAD package itself. Right now, it works with UGS Parasolid models (it handles them directly) and Pro/Engineer (it runs Pro/E in the background to do the CAD cleanup). CATIA V4 capability is promised soon. If demand warrants, MSC says there's no reason why versions for such CAD systems as SDRC I-DEAS, and packages using the ACIS solid modeling kernel, IGES, and VDA can't be offered. It runs in Windows

ware works. Then, I check whether the software, even if it works, might get a sloppy user into trouble.

On review point one, the answer is clear: GS-Mesher works. I could not entirely perform the second check for this review, but I lean toward applause for no other reason than GS-Mesher avoids a translation step from the CAD file to something the mesh generator understands. For the review, I created a little seven-component machine using Autodesk Inventor, then imported the file into Pro/E. I imported it three times — once as perfectly as possible, and twice after creating two different misaligned faces between elements of a complex pawl. When I ran GS-Mesher on the part, it gave essentially the same mesh all three times. But that might have been due to the import process (Inventor and Parasolid are good at cleaning up those little mistakes all by themselves). When I ran Mesher with the part detached from its little machine and redone from scratch in Pro/E, GS-Mesher quickly highlighted the flaw and allowed me to easily fix it.

Here's how it works once you have your CAD model. You simply start GS-

There are two export options — as an MSC.Nastran bulk data file or as an MSC.Patran database. I confirmed the calculations on our simple part (40 faces) by stressing the meshes inside MSC.Nastran, with no further processing. The ex-



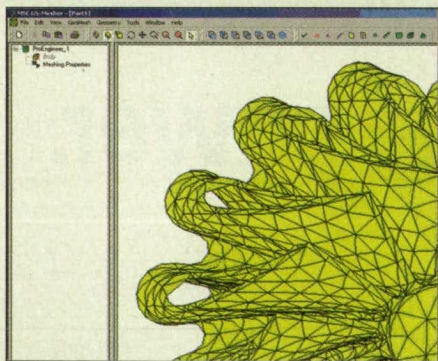
Model part with failed mesh (marked with spheres). Failure reasons are noted on the left.

amples in the figures show how the curvature control works to produce a finer mesh around sharp curves. GS-Mesher outputs solid 3D tetrahedral, surface paved, and 2D triangular meshing.

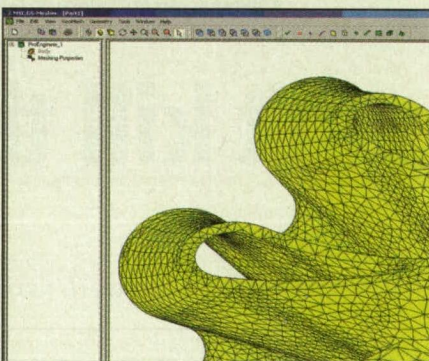
If the mesh fails, the failure points are marked with spheres and an error message appears. The nature of the problems that caused the failures are "called out" in the window at the left of the screen. Clicking on the listings allows you access to each failed point in turn, so that you can specify a fix. You can hide all the faces except those that are causing problems — a boon when the model is as complex as an engine block. GS-Mesher tells the CAD software, running in the background, to fix the problem — intersecting face, bad entity, and so forth.

The copy protection is state-of-the-art. Along with other MSC products, it uses the FlexLM licensing database system. For more information, as well as pricing details, contact MSC Software at 714-540-8900, or visit [www.mscsoftware.com](http://www.mscsoftware.com).

Steve Ross is a visiting professor at Boston University this year, where he co-directs the new Institute for Analytic Journalism.



At left are tips of a turbine modeled with the default 45 degree curvature control. At right are the tips modeled after setting curvature to 15 degrees.



NT or Windows 2000. I reviewed on a new Win2000 machine with 1.6 GHz processor and 512 MB of RAM. Meshes calculated almost instantaneously.

When any vendor brags about fixes in CAD models being automatic, or almost automatic, I tend to get very skeptical. From a quality control standpoint, any software that makes it easier for less experienced personnel to do really complicated tasks requires a two-step reviewing process. First, I check whether the soft-

Mesher, open a blank file, and bring your CAD file in. The model then is examined inside GS-Mesher. The model's faces are automatically assigned different colors for ease of visualization. Create a mesh and change the settings or accept the defaults.

Once the mesh is calculated, you can make it finer in a selected area, and specify a smaller mesh over this face. Click on an icon to draw the whole mesh, and export the mesh.



# Technical projects are a challenge.

Mathcad® 2001 is the most powerful tool for applying mathematics. It is the backbone for your technical desktop applications. With Mathcad 2001, you get faster performance, bi-directional MathML support for viewing and interacting with math in your browser, collaboration tools, powerful simulation and modeling capabilities, full compatibility with the Microsoft® Office suite, MATLAB®, AutoCAD®, and much more.

Now, with the addition of new Mathcad Client, you get a cost-effective way to share interactive technical documents throughout your organization. Isn't it time you standardized on the one corporate solution that ensures all your technical projects run faster and smoother, from start to finish?

# Mathcad

2001

**Better. Faster. More Powerful.**

Also available from your favorite reseller:



Mathcad 2001 Professional includes IBM techexplorer™ Hypermedia Browser - Professional Edition, SmartSketch® LE, Volo™View Express and VisSim LE. With Mathcad 2001 Premium you get everything above plus Axum®, SmartSketch 3 and the Solving & Optimization Extension Pack. Mathcad 2001 runs on Windows 95, 98, 2000 and Windows NT 4.0 or higher. Volume and academic licensing is available.

To order call 1-800-628-4223 or go to [www.mathcad.com](http://www.mathcad.com)

MathSoft

© 2001 MathSoft Engineering & Education, Inc. Mathcad is a registered trademark of MathSoft Engineering & Education, Inc. Axum is a registered trademark of Insightful Corporation. AutoCAD is a registered trademark and Volo is a trademark of Autodesk, Inc. SmartSketch is a registered trademark of Intergraph Corporation. Microsoft and Windows are registered trademarks and Windows NT is a trademark of Microsoft Corporation. MATLAB is a registered trademark of The Mathworks, Inc. IBM and IBM techexplorer Hypermedia Browser are trademarks of IBM in the United States and other countries and are used under license. All rights reserved.





### Saturation Technique for Rapid Binary Image Processing

**This technique is fundamentally different from truncation of least-significant bits.**

*Lyndon B. Johnson Space Center, Houston, Texas*

An improved technique of limited-precision arithmetic has been devised for use in convolutional filtering of image data prior to conversion of the data to binary form. Both limited-precision arithmetic and conversion to binary form reduce the volume of data, thereby contributing to processing speed and reducing the sizes of circuits needed to perform, and store the results of, intermediate stages of process-

ing. This technique was conceived especially for use in processing digitized pixel image intensities by convolutional  $3 \times 3$  (or by equivalent combinations of  $1 \times 3$  and  $3 \times 1$  filters) that perform Gaussian, Laplacian, or Laplacian-of-Gaussian (LoG) opera-

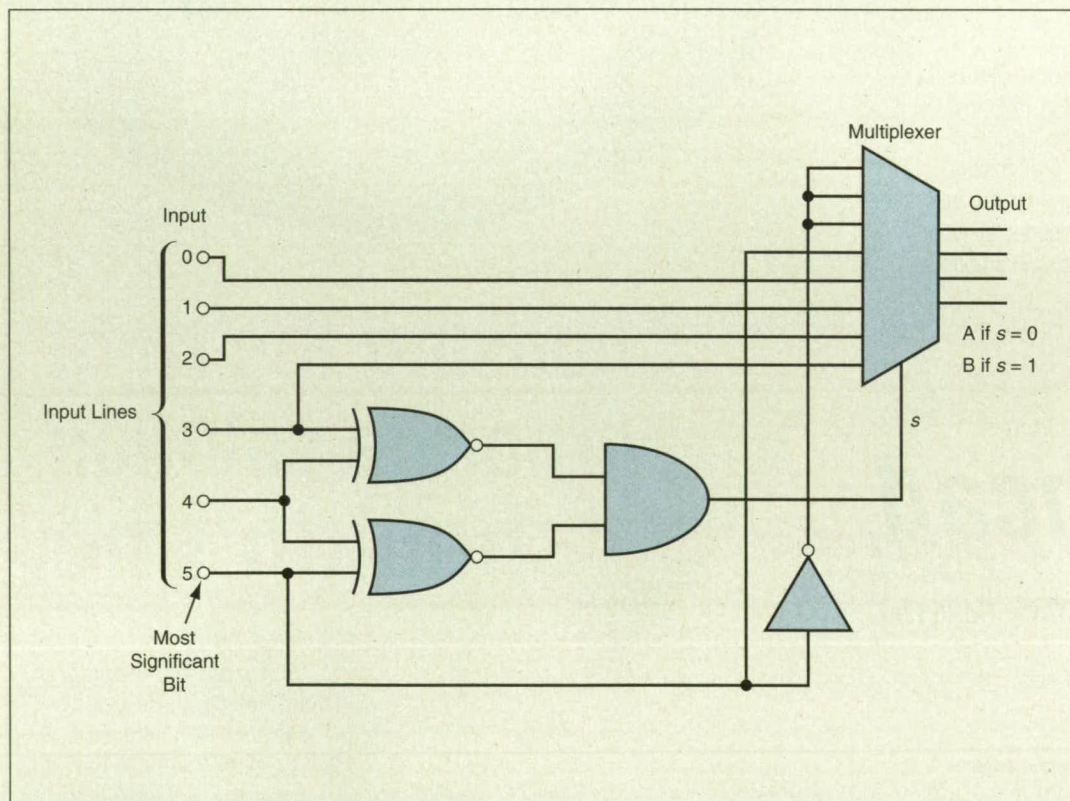
mapping of pixel intensities to binary representation. A Laplacian filter emphasizes edges and texture, while a Gaussian filter smooths out noise.

The preferability of the present saturation-based technique over the conventional truncation-based technique arises in the treatment of intermediate results of Laplacian and Gaussian convolutional filtering of an image. Truncation or rounding sacrifices bits of low

order to preserve the fundamental magnitude of a number as represented by the bits of high order. In the final conversion to binary, the bits of lowest order account for the finest detail in the resultant image. For a pixel value near zero, a change of +1 or -1 in a bit of low order can make a difference in the sign of the binary pixel value, possibly yielding the incorrect binary value (corresponding to a pixel that should be black instead of white or vice versa).

In the present saturation-based technique, one discards high-order bits in such a way as to preserve correct sign of the pixel value in the final conversion to binary. In this technique, each pixel value is exam-

ined and modified as follows: If the value is larger than the largest value that can be represented in the result, then the pixel value is replaced by that largest value. Conversely, if the pixel value is negative or smaller than the smallest value that can be represented in the result, then the pixel value is replaced by that smallest value. The fig-



**This Circuit Generates a Saturated Four-Bit Output** in response to a six-bit input. The exclusive-OR gates examine the number of high-order bits to be eliminated, plus one, to determine whether they are already all alike. If so, the input quantity is deemed to be within the saturation range, and is itself gated through the multiplexer. If not, a maximum positive or negative quantity is derived from the sign bit and gated through the multiplexer. This circuit implements 2's-complement encoding of negative numbers.

ing. Applications in which these techniques are or could be helpful include robotic vision, recognizing and tracking moving targets, stabilizing images in hand-held video cameras, and general enhancement of images.

The improved technique of limited-precision arithmetic involves the use of saturation — the substitution of a spec-

ifications on pixels in  $3 \times 3$  neighborhoods. (Most LoG operations for neighborhoods larger than  $3 \times 3$  can be composed of series of  $3 \times 3$  operations; for example, the LoG for a  $9 \times 9$  neighborhood can be computed by performing four successive  $3 \times 3$  LoG operations.) These filters are typically applied to improve the reliability and consistency of



## What threatens your high speed PCB design?

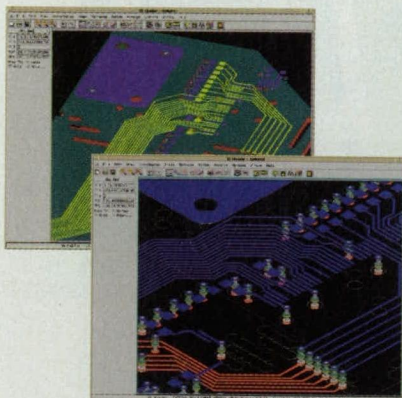
As clock speeds approach 1 GHz even the simplest passive elements cause propagation delay, cross talk, and ground bounce. Eliminate glitches, resets, and logic errors by simulating entire signal paths.

Rely on Ansoft's high performance EDA solutions for your signal integrity and EMI needs.

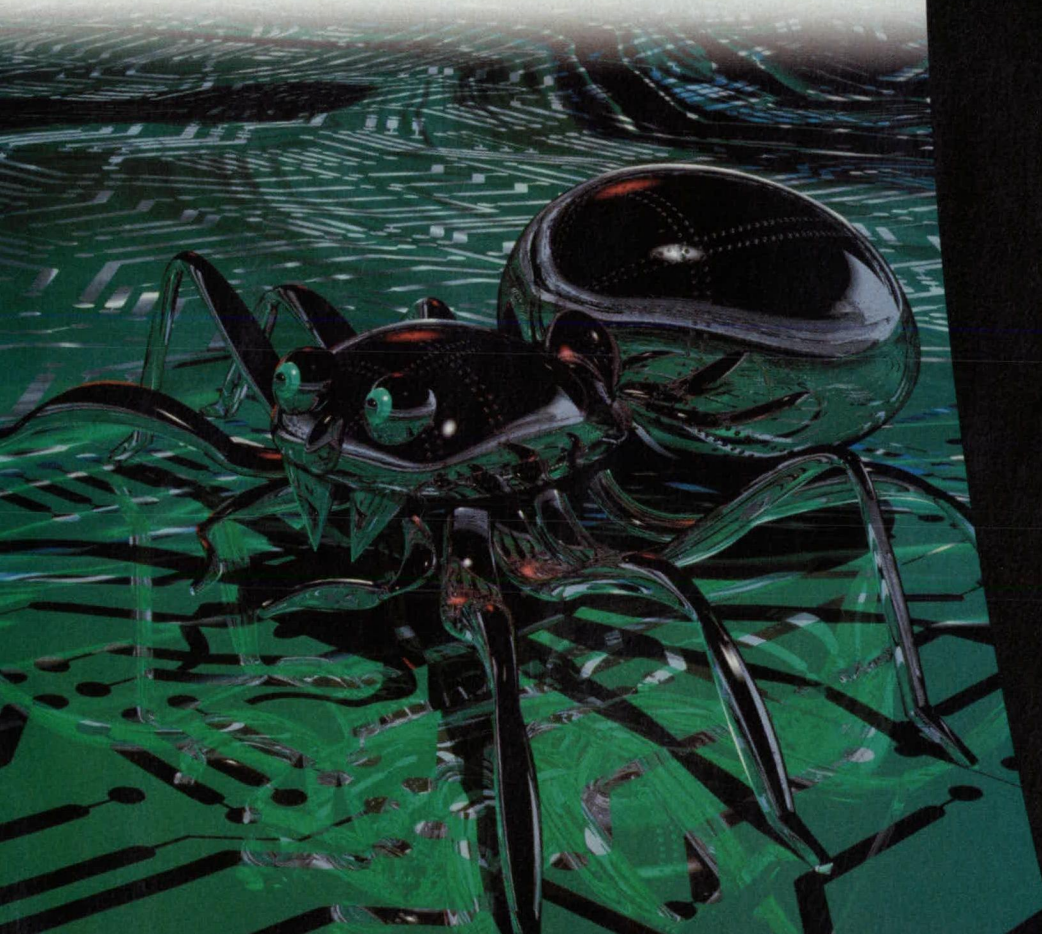
Contact us for a free evaluation at 412-261-3200 or [info@ansoft.com](mailto:info@ansoft.com).

**For Free Info Circle No. 566 or  
Enter No. 566 at [www.nasatech.com/rs](http://www.nasatech.com/rs)**

*Unmatched speed and accuracy in parasitic extraction and signal integrity simulation.*



# Eradicate



**ANSOFT**

[www.ansoft.com](http://www.ansoft.com)



# INNOVATIVE



## ACCURIDE. THE PIONEER IN PRECISION SLIDES AND SOLUTIONS.

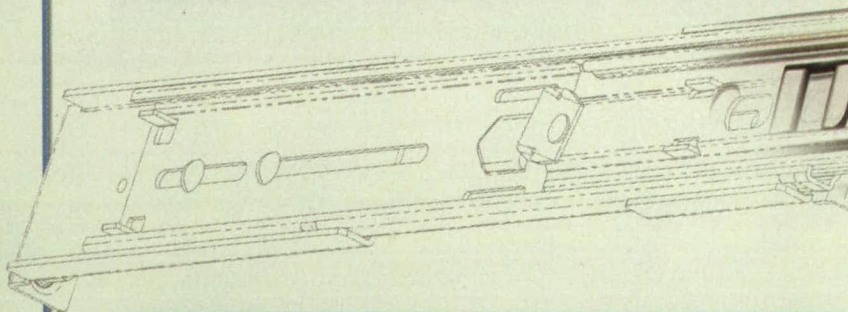
Accuride is the largest company in the world dedicated to the design and manufacture of precision ball bearing slides. For more than 35 years, we've worked side-by-side with our customers to pioneer new applications and solve tough design challenges through sound engineering, expert tooling and innovative solutions.

### MORE SLIDES

- ▶ 8" to 60" in length
- ▶ 35 to 500 lb. load capacity
- ▶ Standard and customized designs
- ▶ Range of brackets and accessories
- ▶ Network of stocking distributors

### MORE SOLUTIONS

- ▶ Engineering and tooling expertise
- ▶ Expert technical assistance
- ▶ Worldwide sales and service
- ▶ Global manufacturing
- ▶ ISO 9001 certified facilities



## Data Acquisition

ure depicts a circuit that efficiently saturates a six-bit input to a four-bit output.

*This work was done by Robert L. Shuler, Jr., of Johnson Space Center. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Mechanics category. MSC-22850*

## Network for Forecasting Weather and Diffusion of Toxins

**This system supplants a slower, less effective system.**

*John F. Kennedy Space Center,  
Florida*

The Meteorological Range Safety Support System/Eastern Range Dispersion Assessment System (MARSS/ERDAS) is a system of interconnected computer workstations designed to acquire, process, and disseminate nearly real-time meteorological data and outputs of mathematical models of the atmospheric diffusion of toxic and otherwise hazardous substances. The MARSS/ERDAS hardware and software were developed to increase the effectiveness of NASA and Air Force range safety personnel. The basic MARSS/ERDAS concept could be adapted to industrial, agricultural, and scientific applications in which there are requirements to forecast weather to protect weather-sensitive assets and/or predict the movements of toxic plumes.

Prior to the development of the MARSS/ERDAS, the forecasting and mathematical modeling functions in question were performed, variously, by use of manual techniques or by use of central processors with asynchronous communications to remote sites. The manual processes required additional personnel for a number of tasks that were highly repetitive and the results of manual processing often included errors. The prior computer system was easily overloaded by user activities, and display updates were slow, because of both the load on the system and a slow communication link. Users were often disconnected and had to wait several minutes for reconnection.

The MARSS/ERDAS features a reliable, expandable, and flexible hardware and software architecture. The



software incorporates a program that implements a mesoscale meteorological model integrated with a program that implements toxic-diffusion-prediction algorithms. More specifically, the software incorporates the following programs: Regional Atmospheric Modeling System (RAMS), Isentropic Analysis (ISAN), Hybrid Particle and Concentration Transport (HYPACT). The system also enables local execution of the REEDM and BLASTX programs. Data displays can include graphics, text, and map overlays. The system can also be made to perform an expert-system meteorological-monitoring function that includes the generation of audible and visible alerts when specified meteorological constraints are violated.

*This work was done by John Warburton, Greg E. Taylor, Allan V. Dianic, and Erik Magnuson of ENSCO, Inc., for Kennedy Space Center.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to*

*Mr. Allan V. Dianic*

*ENSCO, Inc.*

*1980 No. Atlantic Ave.*

*Suite 230*

*Cocoa Beach, FL 32931*

*Tel No: (321) 783-9735*

*E-mail: dianic.allan@ensco.com*

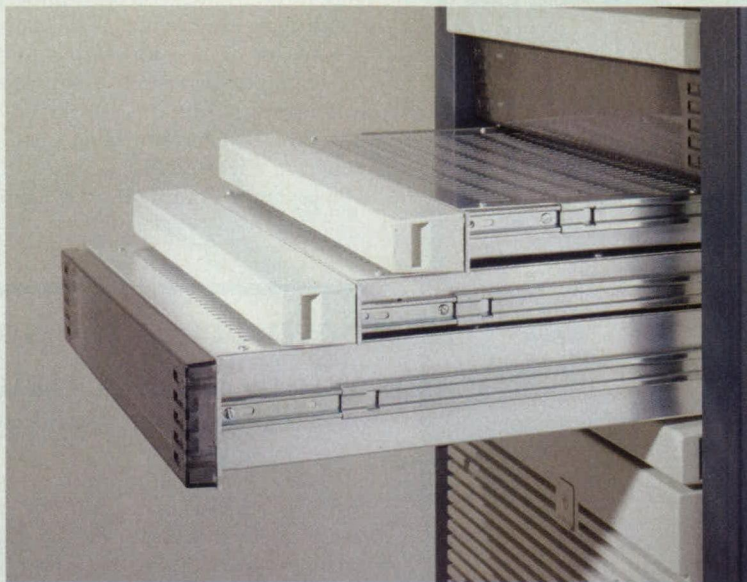
*Refer to KSC-12178, volume and number of this NASA Tech Briefs issue, and the page number.*

## Software for Processing Serial Cross Sections Into 3D Images

*Ames Research Center, Moffett Field, California*

The Reconstruction of Serial Sections (ROSS) computer program processes data from a series of tomograms to generate a three-dimensional (3D) representation of an object, and further processes data from the 3D representation to enable the viewing of any part of the object from any of an essentially unlimited number of perspectives. ROSS is expected to be especially useful for biomedical applications, including medical research, medical training, virtual-environment simulations for planning surgery, and

# INNOVATION



## THE 2807. THE LOWEST PROFILE SLIDE FOR 1U AND 2U CHASSIS.

Introducing the 2807—the industry's thinnest, lowest profile slide for small chassis. This easy-access server slide can be positioned at the top, middle or bottom of the chassis side to leave more room for cooling vents, hot swapping and diagnostic work! It's just another smart product innovation from Accuride.

### MORE ACCESS

- ▶ .375" wide
- ▶ 1.06" high
- ▶ 2" of over travel for access to entire unit
- ▶ Pinch-free friction disconnect

### MORE FLEXIBILITY

- ▶ 60 lb. load rating
- ▶ Attached bracketry for easy installation
- ▶ Accommodates flush-return and U-shaped flanges
- ▶ Even lengths: 10 to 30 inches



**CALL 562-903-0263  
OR VISIT [WWW.ACCURIDE.COM](http://WWW.ACCURIDE.COM)  
FOR YOUR SOLUTION.**

**Accuride®**

*The Leader In Precision Slide Solutions*

This product is covered by U.S. patents issued and pending. ©2001 Accuride International Inc.





## Instant Data Acquisition Right Out of the Box!

No time for custom programming?  
No problem! Just add data and you're off and running, because every ChicoPlus card comes with more than 50 ready to run Turnkey Applications, free of charge! So you don't have to be a C++ expert or a LabVIEW whiz to take advantage of this true Plug-n-Play Data Acquisition Solution!

### Features

- ▶ Perform high-speed multi-channel data acquisition from A/D channels, directly to PC memory or disk
- ▶ Play waveforms from signal generators or disk files to D/A channels
- ▶ Display real-time graphs of acquired data
- ▶ Capture high-speed transients to 40MHz
- ▶ Perform spectral response post-analysis on data
- ▶ Store gigabytes of data to hard disk
- ▶ Scroll through acquired data for review/analysis in time or frequency domains



www.innovative-dsp.com  
805.520.3300 phone 805.579.1730 fax

telemedicine. The main contributions of ROSS to the art of computational 3D imaging are ease of use, high fidelity, and general applicability. Even high-school students have been trained to use ROSS. The fidelity of the images generated by ROSS from tomographic data is great enough that surgeons can notice tiny defects in hearts and lungs, for example. Although a typical set of tomographic data is so large that, heretofore, it has not been possible to generate high-fidelity 3D views by use of a personal computer, ROSS makes it

possible by rendering different components of images at different levels of resolution so that one does not lose sight of essential features and yet the overall amount of information to be processed is reduced drastically.

*This program was written by Muriel Ross, Kevin Montgomery, Samuel Linton, and Rei Chang of Ames Research Center. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Software category.*  
ARC-14035

## Software for Displaying and Comparing Wind-Tunnel Data

*Ames Research Center, Moffett Field, California*

DARWIN is a computer program that provides access, via the Internet, to geographically dispersed NASA computer archives of both meta-data and raw test data from wind tunnels and raw simulation data from computational fluid dynamics (CFD) sites. DARWIN facilitates the manipulation and examination of the raw data by presenting the data in two- and three-dimensional plots, and other visual displays. DARWIN provides a "live" window that can be used during a wind-tunnel test to generate a customized display of newly acquired data in nearly real time. By use of DARWIN, it is possible to display simultaneously, and hence compare, data from different tests or CFD simulations — even from tests performed at different sites or simulations per-

formed on different computers. DARWIN is characterized by a three-tier (server/server/client) architecture: In a wind tunnel or at a CFD site, there is a secure server computer that houses the meta-data and the raw test data. The secure server transmits data files (only) to a central DARWIN server, which interacts with users and processes data according to users' requests while preserving the security of the archives.

*This program was written by David Korsmeyer, Joan Walton, John Schreiner, and Dennis Kroga of Ames Research Center. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Software category.*  
ARC-14376

## Integrated Environmental Monitoring Instrument

**This is a semiautonomous reference instrument with radio-communication and networking capability.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A miniature, battery-powered, semi-autonomous environmental monitoring instrument contains advanced meteorological sensors, a Global Positioning System (GPS) receiver for determining its position, radio-communication circuitry, and a controller that performs measurement, control, and data-communication interface functions. The instrument could serve as a high-accuracy radiosonde, though its

intended use is in providing reference measurements for calibration and comparison of ordinary radiosondes.

The primary functions of the instrument are to periodically measure humidity, pressure, temperature, and position, and to report the measurements to a base station. The base station records the data stream as received, displays key parameters on a screen to enable monitoring of status, and pro-



# IF YOUR IDEA OF LIGHT READING CONSISTS OF CHARTS, GRAPHS AND TABLES, PERHAPS YOU'D LIKE TO JOIN OUR BOOK CLUB.

DuPont™ Vespel®  
forward engineering



Ahh, the visions of  
progress that dance in  
your head: Superior assemblies made



with washers, thrust devices and seal rings that withstand wear. High-performance engines built with bushings, vanes and wear strips that endure high temperatures and provide low friction. Exceptionally clean retainer rings, chamber liners and in-process components durable enough to resist harsh

chemicals. But before you go setting the design world on its edge, you need a range of materials versatile enough to make these visions a reality. Good thing DuPont™ Vespel®

Parts & Shapes are equal to the task. In fact, our expanded new lineup consists of five families of material solutions that provide a unique combination of physical properties, while offering you the ultimate in design flexibility. Starting as the Vespel® S line, the family has grown significantly to include the introduction



of Vespel® TP for maximum geometric flexibility, Vespel® CP for superior heat resistance and strength, Vespel® CR for maximum chemical resistance, and Vespel® ASB, which

combines materials for specific applications. Now more than ever, we have the resources necessary to help you realize your vision from start to finish. With the culmination of our expanded line of products and in-depth technical expertise, it's clear



Vespel® Parts & Shapes are the perfect complement to the mindset



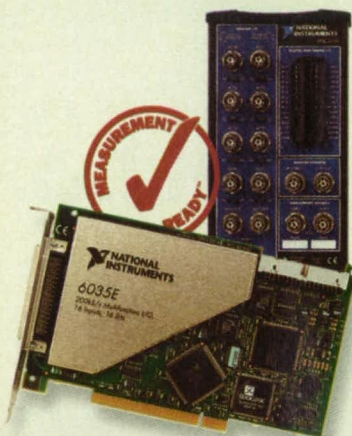
of an engineer focused on not only meeting customer requirements, but breaking new ground as well. After all, making things stronger, faster, lighter, and subsequently, more efficient is what Vespel® Forward Engineering is all about. All things considered, there's never been a better time

to think Vespel® Parts & Shapes early on in the design process. An idea more and more engineers are waking up to. For more information on what our expanded line of material solutions can do for you, go to [www.dupont.com/vespel](http://www.dupont.com/vespel) or call 1-800-972-7252. If you can dream it, we can make it.





# 16-Bit Data Acquisition for \$595



Take 16-bit measurements starting at just \$595\* with National Instruments devices.

16-Bit Device	Sample Rate	Analog Inputs	Analog Outputs
PCI-6034E	200 kS/s	16 SE/8 DI	—
PCI-6035E	200 kS/s	16 SE/8 DI	2, 12-bit
PCI-6052E	333 kS/s	16 SE/8 DI	2, 16-bit
PXI-6052E	333 kS/s	16 SE/8 DI	2, 16-bit

Each device also includes two, 24-bit counter/timers and 8 digital I/O lines.

## Data Acquisition Software

- LabVIEW™
- Measurement Studio™
- NI-DAQ™ driver interfaces to Visual Basic and Visual C++

[ni.com/info](http://ni.com/info)

For more technical information visit [ni.com/info](http://ni.com/info) and enter nagq21.



(800) 327-9894

Fax: (512) 683-9300 • [info@ni.com](mailto:info@ni.com)

© Copyright 2001 National Instruments Corporation. All rights reserved. Product and company names listed are trademarks or trade names of their respective companies.

\* U.S. pricing for PCI-6034E

vides an uplink (radio-communication) interface for sending commands and operational parameters needed for instrument functions.

The meteorological sensors in the instrument are a commercially available micromachined pressure sensor, three commercially available fast-response thermistors, and a surface-acoustic-wave (SAW) hygrometer.

The SAW hygrometer was developed at NASA's Jet Propulsion Laboratory and was described in "Fast, High-Sensitivity Dew-Point/Frost-Point Hygrometer" (NPO-20006), *NASA Tech Briefs*, Vol. 21, No. 5 (May 1997), page 10a. A surface-acoustic-wave (SAW) device serves as the resonant frequency-selecting element of a radio-frequency (RF) oscillator. The frequency of oscillation is sensitive to condensation on the surface of the SAW device. The SAW device is mounted on a thermoelectric cooler, which is used to effect feedback control of the temperature of the SAW device to maintain equilibrium between condensation and evaporation. The feedback-controlled temperature

is near or at the dew or frost point and constitutes a measure of humidity.

Three custom circuit boards incorporated into the instrument drive the SAW device at its resonance frequency, provide signal conditioning, and implement digital control and communication.

In addition to the three custom circuit boards, the instrument contains a GPS receiver and an RF modem.

The base station consists of a laptop computer equipped with an RF modem. In addition to serving as a command and control interface as described above, the base station provides a display of real-time data and a moving map with a superimposed mark that represents the position of the instrument.

*This work was done by Michael E. Hoenk, Robert Watson, and Greg Cardell of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free online at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category.*  
NPO-20582

## Profiling the Atmosphere by Use of an Elevated GPS Receiver

One can estimate the local refractivity of the atmosphere as a function of altitude.

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A method of determining the radio refractivity of the atmosphere as a function of altitude involves processing of data acquired by airborne or mountain-top Global Positioning System (GPS) receivers from particular GPS satellites as those satellites rise above or fall below the horizon. Previously, data of this type ("GPS occultation data" for short) have been gathered from outside the atmosphere by GPS receivers in low orbits around the Earth and used to generate global refractivity profiles. With the help of temperature data from weather analysis, the refractivity profiles can be converted to water-vapor profiles. In contrast, the present method of utilizing data from GPS receivers located within the atmosphere (see figure) makes it possible to obtain refractivity profiles, and thus water-vapor profiles, that are not global averages and, instead, are averaged over smaller geographic regions wherein the GPS receivers are located. Such higher-resolution water-vapor

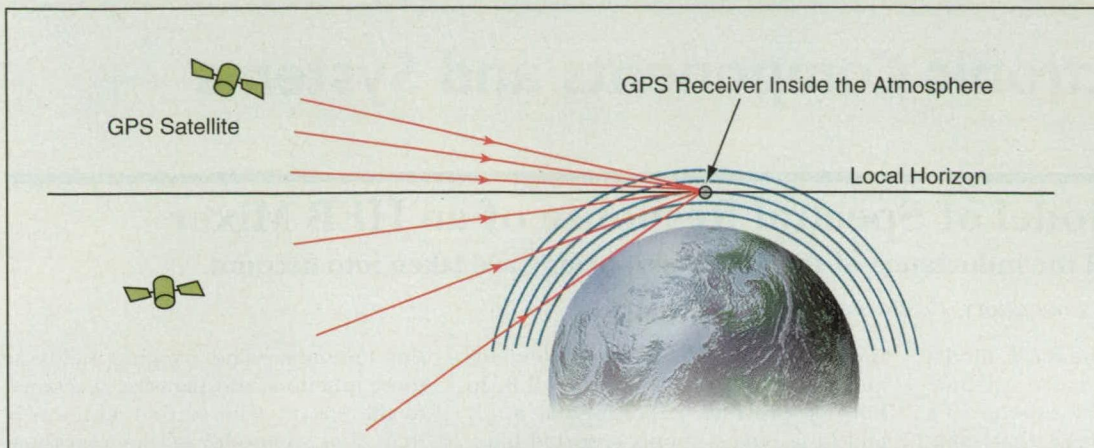
profiles can be used in studies of regional weather.

For a GPS receiver and a GPS transmitter of interest, the raw GPS data used in the method include the phase delays of the L1 and L2 GPS signals, which are at wavelengths of 19.0 and 24.4 cm, respectively. Other GPS data that are needed in this method include the position of the transmitter of interest, the position of the receiver, and the clock data of the receiver and the transmitter of interest as determined partly from data received simultaneously from other GPS satellites.

By a mathematical derivation that greatly exceeds the scope of this article and that involves a ray-tracing model of propagation of GPS signals through a spherically symmetrical atmosphere, one can find the relationships among the data and other variables. Of particular relevance are the following:

- The relationship between the total bending angle ( $\alpha$ ) of a GPS ray and the L1 and L2 phase delays;





GPS Occultation Data Are Acquired by a receiver at a known position within the atmosphere.

- The index of refraction ( $n$ ) of the atmosphere as a function of radius ( $r$ ) from the center of the Earth [ $n(r)$  is the desired information)];
- The parameter  $a$  in the equation obtained by applying Snell's law of refraction to a ray propagating through a spherically symmetrical atmosphere [this equation is  $n \sin(\phi) = a$ , where  $\phi$  is the local angle between the direction of propagation and the radius vector]; and
- An equation, derived from the pre-

ceding equation, that expresses the bending as an integral function of  $n$ ,  $r$ , and  $a$ :

$$\alpha = -2a \int_a^{\infty} \frac{1}{n \sqrt{n^2 r^2 - a^2}} \frac{dn}{dr} dr.$$

In this method, the refractivity of the atmosphere is modeled as piecewise exponential with a scale height that changes from one atmospheric layer to the next. The scale heights and a normalizing value of refractivity are re-

trieved by minimizing, in a least-square sense, differences between (1) bending angles and refractivity determined from GPS data and (2) corresponding quantities obtained from the exponential model and ray-tracing.

The method has been tested by computational simulation for the case of a GPS receiver at an altitude of 5 km.

The results of the test have been interpreted as suggesting that the method yields accurate profiles of refractivity at heights ranging from ground level to slightly above the receiver.

*This work was done by Cinzia Zuffada, George Hajj, and Robert Kursinski of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free online at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category. NPO-20704*



# FLUKE®

## Fluke Data Acquisition.

### The complete picture in data acquisition.

Fluke offers portable, wireless and networked data acquisition tools to let you transfer data where you want it, when you want it, and in the form you want it. From our small, easy to use, portable Hydra Series to the large plant wide system capacity of our NetDAQ networked data acquisition units. Fluke has a data acquisition product to fit your needs.

All products come with Fluke's patented universal input module, which means you'll never have to buy extra signal conditioning modules to do your job. We have the speed, accuracy, isolation, and reliability you need to get the job done right, and our advanced trend analysis and reporting software helps the data you collect go to work for you...right away.

**Call 1-888-819-1858**

today for a free software demo disk or visit our website at [www.fluke.com](http://www.fluke.com) to download it.



## Portable, wireless, networked.

**Fluke. Keeping your world up and running.**

© 2000 Fluke Corporation. U.S. (800) 44-FLUKE. Fax back (800) FLUKE FAX. Canada (800) 36-FLUKE. Europe (31 40) 2 678 200. Other countries (425) 366-5500. All rights reserved. Ad No. 01236





### Improved Model of Spectral Response of an HEB Mixer

Fringing fields and the inductance of the HEB microbridge are taken into account.

NASA's Jet Propulsion Laboratory, Pasadena, California

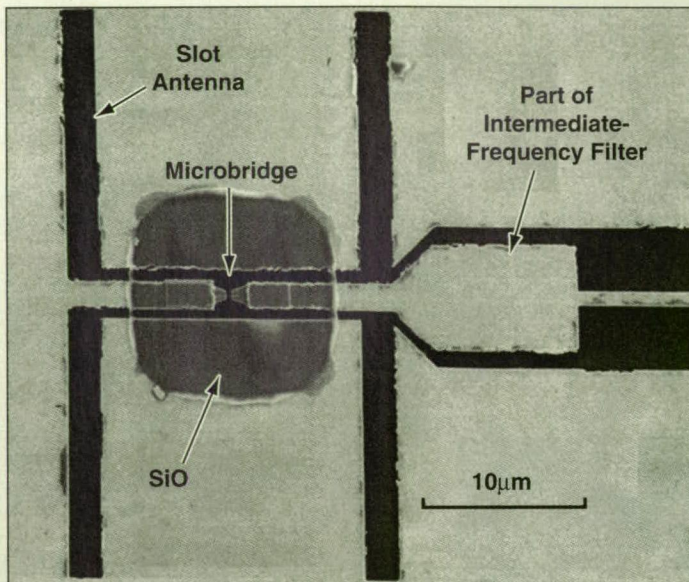
An improved mathematical model enables the somewhat more accurate prediction of the spectral response of a mixer circuit (see figure) that comprises a twin-slot antenna coupled via coplanar waveguides to a hot-electron bolometer (HEB). The development of the improved model is part of a continuing effort to understand and overcome the limitations of circuit models in order to enhance capabilities for designing and analyzing heterodyne mixers to operate at frequencies in the terahertz range.

The improved model was developed in conjunction with, and tested in, experiments that involved measurements of the direct-detection and impedance spectra of HEB mixers that had been designed and predicted, by use of the prior model, for resonance at various nominal frequencies from 0.6 to 2.5 THz. The point of departure for the development of the improved model was a prior model implemented in a method-of-moments computer code. The prior model is a simplified one in that it accounts for the slot antennas and the coplanar-waveguide embedding circuit, but not for the parasitic effects associated with

the couplings of these circuit elements and with the geometry of the HEB. In both a previous experimental study and in the experiments reported here, the measured frequencies of peak di-

slot antennas. The fringing fields at these junctions add parasitic reactance to the circuit. The second addition is that of a submodel of the reactance (predominantly inductive) of the very

narrow HEB microbridge and of the tapered transition pieces, if any, with which it is connected to the center conductors of the coplanar waveguides. These additions exert a small effect on the real part of the embedding impedance, but a large effect on the imaginary part. The predictions obtained by use of the improved model show that in a typical case, the inductance of the narrow HEB microbridge dominates the estimated shift in the resonance frequency below that of the prior model. However, because the results of the experiments showed that the improved model does not account for all of the observed frequency



This HEB Mixer was designed to operate at a frequency of 2 THz. The HEB is a submicron-size device embodied in the microbridge indicated in the middle.

rect detection response were found to be of the order of 20 percent lower than the resonance frequencies predicted by use of the prior model.

The improved model is an extension of the prior model, incorporating two major additions: The first addition is that of a submodel of the junctions between the coplanar waveguides and the

shift, it is apparent that further refinements of the model are still necessary.

This work was done by Andrea Neto and Rolf Wyss of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Electronic Components and Systems category. NPO-21075



### Improved Charge-Termination Technique for Lithium-Ion Cells

Charge/discharge balance is more accurate than that achieved by a conventional technique.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved charge-termination technique has been developed to obtain a more accurate balance between charge and discharge of rechargeable lithium-ion-based electrochemical cells and batteries. The technique has been demonstrated experimentally and is

now in use in a laboratory battery charger. The technique could readily be implemented in the electronic control circuits of battery chargers for consumer electronic equipment.

The conventional charging technique, recommended by manufactur-

ers, involves (1) charging a cell in a current-limited, constant-supply-voltage mode until the cell potential reaches 4.100 V, then (2) allowing the charging current to taper off for about an hour before terminating the charging process. Measurements have shown that



A true pioneer  
in data acquisition  
wouldn't offer you  
just one choice.



The simple fact is that no single solution—be it plug-in or instrument based—is right for every application. That's why Keithley offers both. And we're the only company that does, which means you can trust us to be completely objective about which solution is right for you. What's more, every solution we offer is as reliable and accurate as they come. After all, we helped



pioneer this industry over 50 years ago. So if you're looking for someone to shed a little objective light on your data acquisition problems, log on to [keithley.com/dac](http://keithley.com/dac) and download your **FREE StraightStuff Data Acquisition Kit**. It's the first step toward making buying decisions based on what's right for your application. Isn't choice a wonderful thing?

Learn more at 1.888.KEITHLEY or [www.keithley.com](http://www.keithley.com)

**KEITHLEY**

A GREATER MEASURE OF CONFIDENCE



the conventional arbitrary time-based cutoff does not guarantee balance between the amounts of electric charge withdrawn and restored during discharge and recharge, respectively.

In the improved technique as in the conventional technique, one charges a cell in a constant-supply-voltage, current-limited mode. However, instead of terminating the charging process after an arbitrary amount of time, one terminates it when the charging current has decreased to  $C/100$  amperes, where  $C$  denotes the nominal charge capacity of the cell in ampere-hours. [If the

amount of time available for charging is not sufficient for tapering down to  $C/100$ , then an alternative minimum current (e.g.,  $C/50$ ) can be used.] In experiments at operating temperatures from 10 to +40 °C, the  $C/100$  cutoff criterion has been demonstrated to return between 0.99 and 1.01 times the amount of charge removed during the previous discharge.

For safety, it would be advisable to augment a  $C/100$  charge-termination trigger with a secondary trigger that terminates charging when the charge/discharge ratio reaches 1.01. This sec-

ondary trigger would help to prevent further damage in the event that a short circuit develops in the cell, preventing tapering of the charging current.

*This work was done by David Perrone of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free online at [www.nasatech.com](http://www.nasatech.com) under the Electronic Components and Systems category. NPO-20358*

## THE ONLY WAY TO SEAL IT SHUT IS TO PNEUMA-SEAL IT

Pneuma-Seal® inflatable gaskets are pressurized with air to fill the uneven gaps between surfaces. When deflated, they quickly retract preventing interference when opening and closing a door or cover. Pneuma-Seal is an effective barrier against pressure differentials, and seals out water, dust, gas, chemicals, noise and other contaminants. Typical applications include:

- Processing Equipment: chemical, food, textile, pharmaceuticals, dryers, ovens and where rapid sealing and unsealing are required.
- Semiconductor Fabrication
- Pollution Control
- Laboratory Facilities
- Transportation
- Construction

Pneuma-Seal is particularly suitable in:

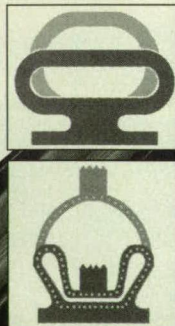
- Large enclosures where it is uneconomical to machine the entire sealing surface.
- Uneven fabrications where traditional compression gaskets or latches are ineffective.
- Horizontal or vertical sliding doors or covers that tend to drag on and abrade conventional seals.
- Hinged doors where flush thresholds are required.

For complete details on profiles, configurations, and applications, visit our website at: **[www.presray.com](http://www.presray.com)**



**PNEUMA-SEAL®**  
manufactured by  
**PRESRAY**

Presray Corporation  
159 Charles Colman Blvd. • Pawling, NY 12564 USA  
(845) 855-1220 • Fax: (845) 855-1139  
West Coast: (949) 475-9842 • e-mail: [info@presray.com](mailto:info@presray.com)

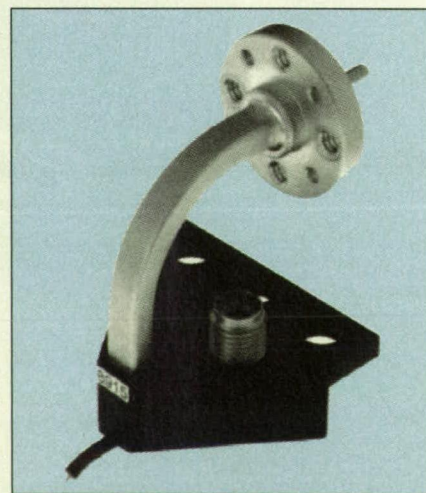


## Equipment for On-Wafer Testing at Frequencies Up to 220 GHz

**Faster circuits can be tested  
more easily than before.**

*NASA's Jet Propulsion Laboratory,  
Pasadena, California*

A suite of electronic test equipment has been developed for use in the measurement of key electrical characteristics of advanced, high-speed integrated circuits for communications, radar, digital networks, imaging systems, and other applications. More specifically, the test equipment is designed to enable the determination of noise figures and of scattering parameters (commonly denoted "S" parameters) at



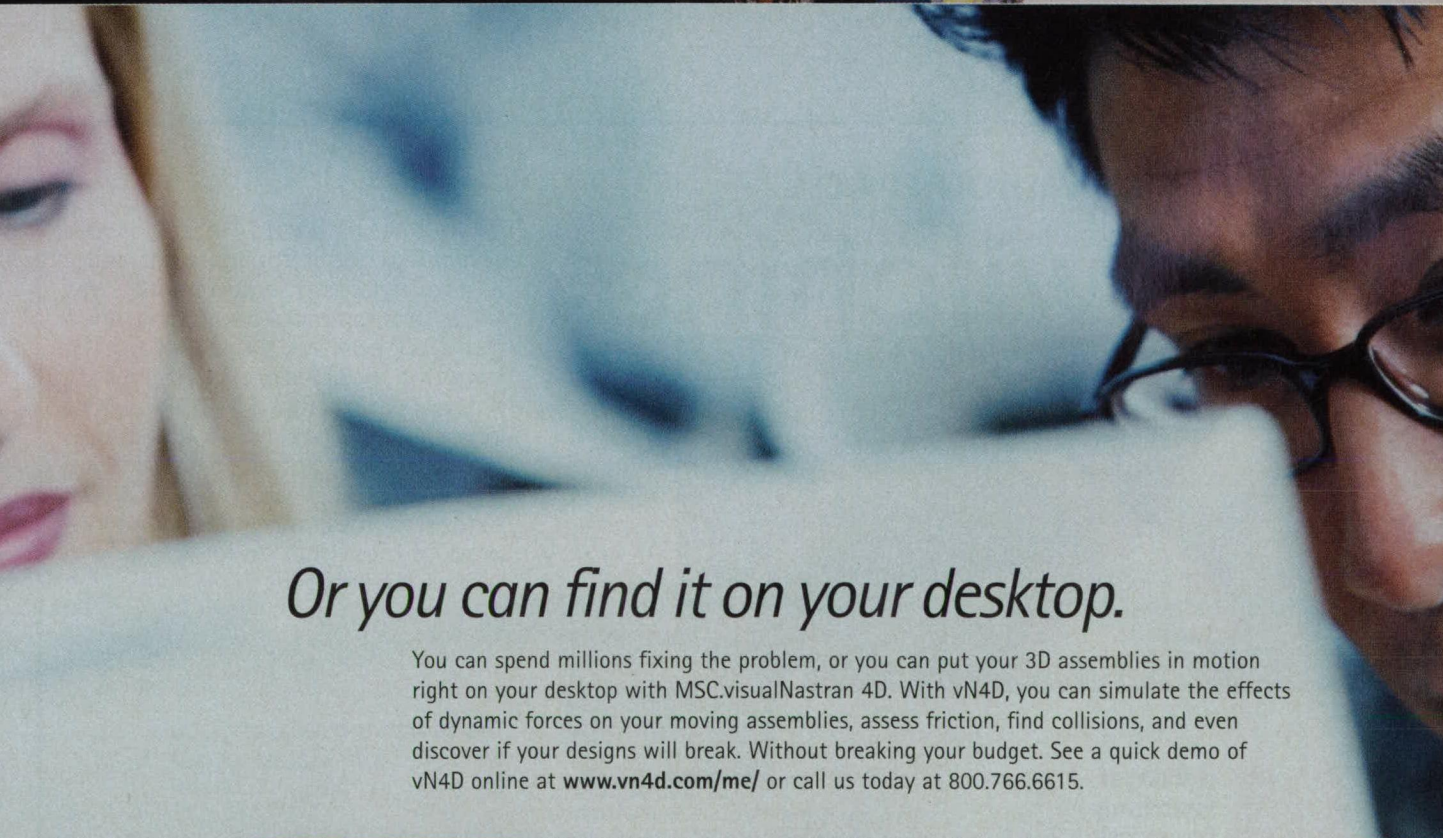
This Coplanar Wafer Probe includes a short coaxial probe body coupled to a WR-5 waveguide section for connection to test instruments. The probe is designed for 220 GHz, but the design can readily be extended to >300 GHz.

frequencies up to 220 GHz. The equipment includes (1) test sets that are basically extended versions of commercial network analyzers that, heretofore, have been functional up to 110 GHz; (2) recently de-





*You could ship 12,000 units  
with a rotational imbalance.*



## *Or you can find it on your desktop.*

You can spend millions fixing the problem, or you can put your 3D assemblies in motion right on your desktop with MSC.visualNastran 4D. With vN4D, you can simulate the effects of dynamic forces on your moving assemblies, assess friction, find collisions, and even discover if your designs will break. Without breaking your budget. See a quick demo of vN4D online at [www.vn4d.com/me/](http://www.vn4d.com/me/) or call us today at 800.766.6615.

MSC.evisualNastran  
Simulation, motion, and  
stress online—anywhere.

MSC.visualNastran Desktop  
Motion and stress simulation  
on your desktop.

MSC.visualNastran Professional  
Powerful analysis on  
the Windows platform.

MSC.visualNastran Enterprise  
World's leading mission-critical  
analysis software.

[www.vn4d.com/me/](http://www.vn4d.com/me/)

4Q11

M S C . v i s u a l N a s t r a n 4 D

**MSC SOFTWARE**  
SIMULATING REALITY

For Free Info Circle No. 559 or Enter 559 at [www.nasattech.com/rs](http://www.nasattech.com/rs)



veloped millimeter-wavelength-signal probes that make it possible to take accurate on-wafer measurements; and (3) an amplifier-based solid-state noise source.

In commercial network analyzers, coverage of frequencies from 50 to 110 GHz is typically accomplished by use of frequency-extension modules that contain multipliers and harmonic mixers. The basic frequency-extender concept is readily applicable to frequencies up to 220 GHz and possibly as high as 325 GHz. Accordingly, the present 220-GHz test sets were developed on the basis of this concept, and were designed to satisfy the following criteria:

- The configuration of the frequency-extension modules must follow accepted industry practice and must be such that one can obtain  $S_{11}$  and  $S_{21}$  by use of a minimal test system and can obtain all four "S" parameters ( $S_{11}$ ,  $S_{12}$ ,  $S_{21}$ , and  $S_{22}$ ) by use of a complete test system.
- The intermediate frequency (IF) use in the test set must be compatible with the most common commercial open-architecture network analyzers.
- The signal radio frequency (RF) and the local-oscillator (LO) drive requirements must be chosen with cost acknowledged as a major design constraint.

Heretofore, in order to measure the electrical characteristics of circuits at frequencies above 100 GHz, it has been necessary to package the circuits into waveguide blocks; this practice is slow and cumbersome, and often does not yield true circuit performance. In contrast, by enabling accurate on-wafer measurements, the recently developed signal probes included in the present test equipment can be expected to foster commercialization by making it possible to characterize circuits accurately, in rapid succession, at relatively low cost.

The figure depicts one in a line of coplanar probes designed for testing millimeter wave circuits. The probe tips, made of beryllium-copper, are individually spring-loaded for reliable connections even to nonplanar circuit structures. A bias T is included to provide current (up to 1.5 A) to the circuit under test and includes loss elements to absorb signals below the waveguide cutoff frequency (115 GHz in this case), where the waveguide becomes highly reflective. Special miniaturized coplanar calibration substrates have been developed for use with this and the other probes.

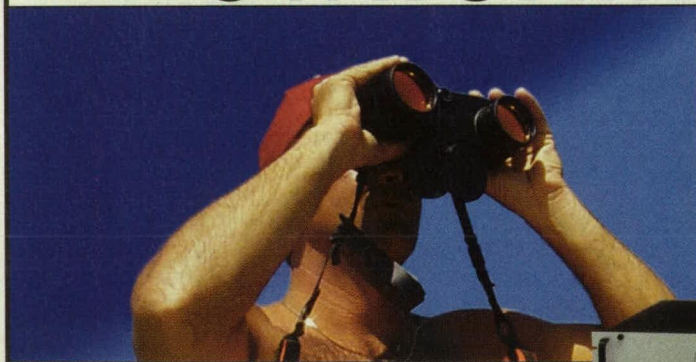
In tests of a receiver circuit, it was found to be cumbersome to perform

noise measurements by use of alternate hot and cold loads in front of a feed horn attached to a wafer probe. Therefore, a transfer standard was constructed: An amplifier with a frequency range of 150 to 190 was packaged into a waveguide block. With its input terminated and its output attenuated to provide a stable output impedance, the amplifier proved to be an ideal semiconductor noise source with an excess-noise ratio of 10 dB. The estimated error in the noise figure measurement is less than 1 dB.

The use of the amplifier as a noise source makes it possible to use a commercial noise-figure meter as an IF processor. This, in turn, enables optimization of biases of circuits under test. In contrast, optimization of bias during testing with hot and cold loads has proved to be a tedious task that has yielded inaccurate results.

*This work was done by Todd Gaier and Lorene Samoska of Caltech, Charles Oleson of Oleson Microwave Labs, and Greg Boll of GBB Industries for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Electronic Components and Systems category. NPO-20760*

## Looking for Automated Switching?



Is your engineering team always **searching** about for the right automated switching equipment? We know programmable switching since that's our business. Our switching systems and modules are available from simple 1x2 units to full 512x512 switching arrays spanning DC to 40GHz, and 10uA to 90A. Solid-state, relay and digital products are offered in our extensive rack mounted or VXIbus product lines. High performance and feature loaded,

.....yet cost effective.



Rack-mounted systems  
(1RU to 9RU)

**The search is over!** Check our web-site for the latest, or call for a free catalog.

## It's what we do!

**US** Universal  
Switching  
Corporation

7145 Woodley Avenue  
Van Nuys, CA 91406 USA

Phn: +1 818-785-0200  
Fax: +1 818-785-0680  
Email: [sales@uswi.com](mailto:sales@uswi.com)  
Web: [www.uswi.com](http://www.uswi.com)

**Audio - Video - NTSC - RGB - Digital - RF - IF - ATE - Telemetry - Cellular - Microwave**



# These won't save you time or money ...

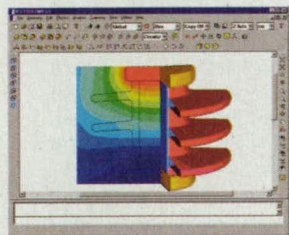
$$\nabla \times \mathbf{H} = \mathbf{J} + \epsilon \frac{\partial \mathbf{E}}{\partial t} \quad \nabla \times \mathbf{E} = -\mu \frac{\partial \mathbf{H}}{\partial t} \quad \nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon} \quad \nabla \cdot \mathbf{H} = 0$$

## THESE WILL



A CAE electromagnetic package that immediately boosts productivity and saves prototyping costs is hard to find. That's where our line of innovative boundary element method (BEM) simulation software can help.

We've designed each of our packages around three basic principles: **advanced technology; productivity and outstanding customer service.**



A clean, intuitive, user interface means the software is easier to use and learn than most other electromagnetic CAE tools.

### Advanced Technology

We use Integrated's software to model precision magnetic circuits for the reprographics industry as well as other electromagnetic applications. The software enables us to create extremely accurate virtual results. This has allowed us to greatly reduce our prototype-to-production phase."

**Group Arnold**  
Magnetic Technologies Corp,  
Rochester, NY.

Advanced features like our intuitive user interface, extensive materials library, powerful solvers, exportable data and graphics, flexible post processing options and powerful parametric optimization routines give you the most sophisticated programs available anywhere. In addition, our coupled electromagnetic/mechanical suite gives you complete solutions.

### Productivity

"Integrated's software offers Industrial Coils the ability to model our designs quickly and accurately. Our design time has been reduced from three weeks down to two and a half days.

**Mike Potter**  
Assistant Engineering Manager,  
Industrial Coils,  
Baraboo, WI.

You'll be producing useful designs in a matter of hours! We provide you with sample sessions to work through, on-line help, web support and full technical and application support to help you solve your toughest design issues. You also get industry standard links that connect you to your favorite CAD program for easy file import/export, shortening your design process even further.

In just minutes, install your program on your desktop PC. Within one day begin working on,

and solving your own designs. In just one week, solve even the most challenging and sophisticated 3D designs.

### Ease and Accuracy

"We are using Amperes to model the recording process for both the writing and reading of high density data storage apps. We are very impressed with the user friendliness and accuracy of the program."

**Dr. Sakhrat Khizroev**  
**Dr. Dimitri Litvinov**  
Seagate Technologies  
Pittsburgh, PA.

### Solution capabilities include:

- magnetostatics
- eddy currents
- electrostatics
- charged particle
- high frequency
- mechanical
- thermal
- And more ...

### Yours FREE for 30 days ...

Call 204-632-5636 to order your free, no-obligation demo kit complete with:

- Tutorials

- Quick-start guide
- Full technical support
- Full user support
- Sample sessions
- Technical papers
- All FREE ...



Your FREE Demo kit will have you working in a matter of hours.

## Try it FREE

## Call today:

## 1-204-632-5636

**INTEGRATED**  
ENGINEERING SOFTWARE

Web: [www.integratedsoft.com](http://www.integratedsoft.com)  
E-mail: [Info@integratedsoft.com](mailto:Info@integratedsoft.com)



## 2 Software for Ground Operations for a Prototype Mars Rover

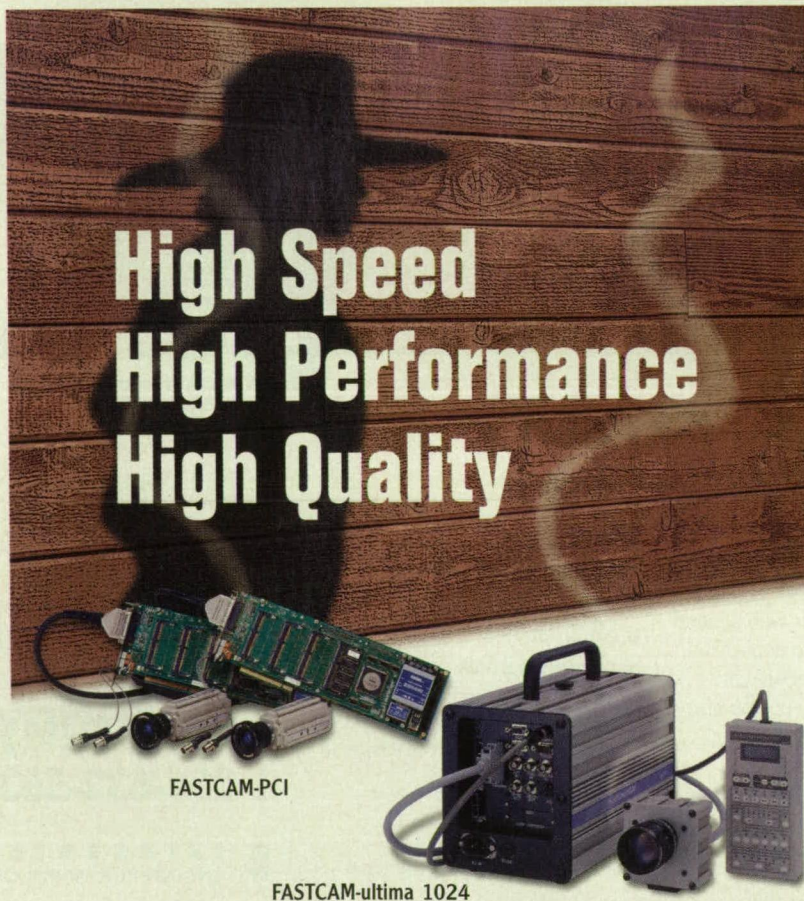
A software system has been developed for use in Earth operations centers communicating with a robotic exploratory vehicle (rover) on Mars. The software was designed for and field-tested on the Field Integrated Design and Operations rover — a prototype similar to rovers of the planned 2003 Mars Explorer Rover mission. The software subsystems and their functions include the following: (1) The Parallel Telemetry Processing (PTeP) system processes downlink data and stores data products in a database. (2) The Multi-mission Encrypted Communication System (MECS) provides communication between a primary terrestrial operations center and geographically distributed, Internet-based users. (3) The Web Interface for Telescience [WITS

(aspects of which have been described in several prior NASA Tech Briefs articles)] displays information downlinked from the rover — video images from several rover cameras and alphanumeric data. Data are coregistered, and uplink targets are coregistered with downlink data. The WITS enables geographically dispersed users to collaborate in the generation of a sequence of commands to be uplinked to the rover, assisting the collaboration by analyzing resources, checking for adherence to rules, automatically correcting errors in the sequence, and predicting (through simulation) the states of the rover at various points in the sequence.

*This program was written by Paul Backes and Jeffrey Norris of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Software category. NPO-21235*

## 3 Software Processes SRTM ScanSAR Data Into Topographical Maps

A computer program automatically generates topographical maps from data collected by scan-mode synthetic-aperture radar (scanSAR) during the Shuttle Radar Topography Mission (SRTM). A preprocessing subprogram subdivides the SAR data, along with ancillary spacecraft-motion, control, and calibration data, into latitude bands called peg regions and puts out the data in a coordinate system and format appropriate for a processing subprogram. The main function of the processing subprogram is to generate strip maps from the preprocessed data, by use of an algorithm developed previously for airborne interferometric SAR mapping and modified to accommodate the burst mode of collection of SAR data of the SRTM (each burst nor-



**High Speed**  
**High Performance**  
**High Quality**

FASTCAM-PCI

FASTCAM-ultima 1024

### FASTCAM

That's why you've chosen Photron FASTCAM systems as the industry standard high-speed imaging products.

Now, we bring you more of what you've come to expect from Photron!

Photron announces direct product distribution and support in the United States and Europe. Contact us — [image@photron.com](mailto:image@photron.com), by telephone at 1-800-585-2129 or face-to-face at your facility. Photron's experienced personnel understand your applications and are always ready with the answers to all your questions.

Here's what we mean! Up-to-date and up-to-speed! Launched in early 2001, the FASTCAM-Ultima 1024, developed around the latest C-MOS imaging sensor using cutting-edge technologies, provides the world's first megapixel resolution high-speed digital imaging system with 500 fps full frame operation and frame rates up to 16,000 fps with reduced resolution.

The FASTCAM-PCI provides an economical PCI card-based, high-speed camera solution. The system offers flexible operation at frame rates from 250 to 10,000 fps as an image-capturing peripheral device for the PC.

There's more like this at — [www.photron.com](http://www.photron.com).

## PHOTRON

Photron USA

Phone: 1-800-585-2129

[image@photron.com](mailto:image@photron.com)

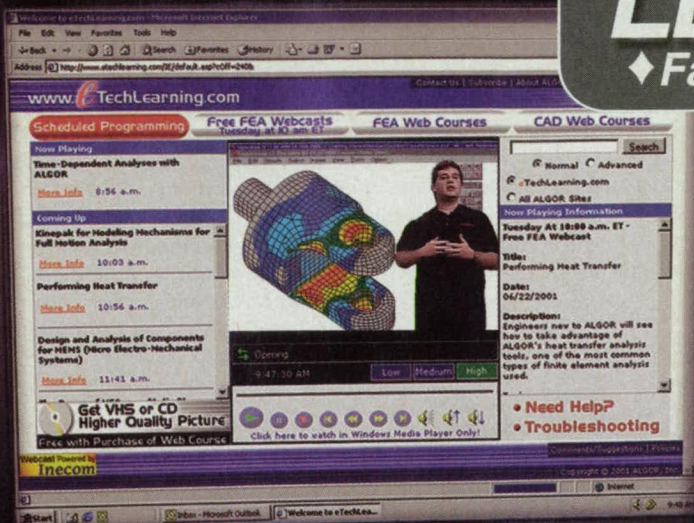
Photron Europe

Phone: +44 (0) 1628-89-4353



# LEARN MORE

♦ Faster ♦ With Less Expense



## with ALGOR Distance Learning Webcasts and Web Courses

Participate in ALGOR's Internet-based distance learning Webcasts and Web Courses and save time and money on training — there's no need to travel or spend time outside the office to learn more about ALGOR software and finite element analysis.

- Streaming audio and video broadcasts provide full-screen, television-quality graphics with instructors showing point-and-click details of using the ALGOR software right on your desktop.
- Viewers can participate in live broadcasts or watch past sessions on demand.
- Internet delivery both eliminates travel costs and time outside the office and enables multisite participation.

# www.eTechLearning.com

Webcast Powered by  
**Inecom**

ALGOR's distance learning Webcasts and Web Courses broadcast at [www.eTechLearning.com](http://www.eTechLearning.com) via full-motion, full-audio streaming media. You can even interact via a talk-show phone system or by e-mail with the ALGOR engineers who conduct the point-and-click, keystroke-specific software demonstrations and training.

Either participate in live or view on-demand distance learning sessions at [www.eTechLearning.com](http://www.eTechLearning.com). Broadcast types include:

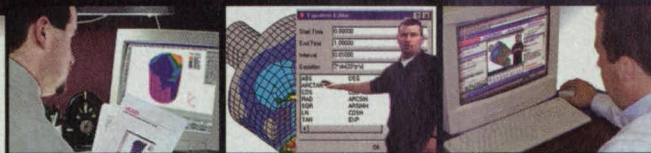
- free software demonstration Webcasts;
- in-depth software training Web Courses; and
- customized software demonstrations and training.

### FREE SOFTWARE DEMONSTRATION WEBCASTS

ALGOR's weekly, live Tuesday at 10:00 a.m. Eastern Time Webcasts provide free, one-hour software demonstrations on new product developments and application-specific topics.

### IN-DEPTH SOFTWARE TRAINING WEB COURSES

With ALGOR's in-depth Web Courses, you can participate in a four- or eight-hour training session right at your desk. Topics include finite element modeling; CAD/CAE integration; Static Structural, Linear Dynamic, Thermal, Electrostatic, Fluid Flow, Multiphysics and Mechanical Event Simulation (MES)



software; and more. Registration includes a CD-ROM or VHS reference copy, unlimited Web viewing access and a certificate for earning Professional Development Hours to fulfill Continuing Professional Competency requirements for P.E. (Professional Engineer) license renewal.

### CUSTOMIZED SOFTWARE DEMONSTRATIONS AND TRAINING

ALGOR can customize product demonstrations for one- or multi-site presentation that show how to analyze your products with our software.

Choose the format that fits your training needs, and learn faster with less expense with ALGOR's distance learning.

♦ **ALGOR**®

When Engineering Has to Be Right  
US Phone: 1.412.967.2700  
Europe (UK): 44.1784.442.246  
Fax: 1.412.967.2781  
California: 1.714.564.0844  
[www.eTechLearning.com](http://www.eTechLearning.com)  
E-mail: [educate@algor.com](mailto:educate@algor.com)  
150 Beta Drive  
Pittsburgh, PA 15238-2932 USA



mally comprising between 50 and 80 pulses). The SAR burst mode stands in contrast to the traditional SAR strip mode, in which every target is illuminated for the entire along-track width of the radar beam. The processing sub-program generates burst-level interferograms, then combines interferograms from multiple bursts in such a way as to generate accurate topographical maps. Results of processing thus far indicate that the program is working as intended and confirm the expectation that the program will generate the first

globally consistent digital elevation map of the Earth.

*This program was written by Scott Hensley, Paul Rosen, and Eric Gurrola of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Software category.*

*This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-21205.*



## Algorithm for Autonomous Visual Discovery

An algorithm that can discover potentially interesting objects in image data has been formulated and implemented in software. The algorithm is intended for applications in which the target objects are mathematically ill-defined and/or not known or specified in advance. Potential applications include finding localized geological features, locating defects in fabrics, and identifying fossils in rock samples. The algorithm, which is based loosely on the human visual system, looks for regions of the image that differ significantly from the local background context. Regions of the image are projected into a subspace by use of multi-orientation, multi-scale Gabor filters. Within this filter-response subspace, deviant areas are identified by use of an adaptive statistical test in which the filter-space description of the region is compared with a mathematical model derived from the local background. Deviant areas are then spatially agglomerated and grouped across scale. In preliminary computational experiments on planetary images collected with various instruments (optical cameras, imaging radar, and ground-based telescopes), the software, without specifically being told what to look for, was able to autonomously rediscover a number of well-known geological features, including impact craters, volcanoes, dunes, and ice geysers.

*This program was written by Michael Burl, Charles Fowlkes, and Dominic Luchetti of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Software category.*

*This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-21107.*



## Computer Program Generates Test Cases

An Automated Test Case Generator computer program generates parameter-based test cases for testing software and hardware systems. Given  $N$  parameters — each of which represents a kind of variation for testing — and a finite set of possible values for each parameter, the program generates individual test cases by selecting a value for each parameter. Collectively, test cases cover the space of possible combinations to a degree specified by the user. The pro-

**MAGNETIC SHIELD**

**The Perfect Shield**  
for magnetic interference problems

...and custom engineered solutions by shape, size & configuration and finish using co-netic® or netic® alloys and foils for your OEM applications

©2001 Magnetic Shield Corporation  
co-netic & netic—RegTM Magnetic Shield Corporation

**FREE Magnetic Shield Calculator**  
... ask for it today!

**MAGNETIC SHIELD CORP.**  
CO-NETIC  
NETIC  
PERFECTION MICA CO.

Visit our web site for "Magnetic Shielding Lab Kit & Catalog Guide"... eliminate EMI in your OEM designs.

**MAGNETIC SHIELD CORP.**  
740 N. Thomas Dr., Bensenville, IL 60106

**TOLL-FREE 800-495-5665**      **IMMEDIATE [magneticshield.com](http://magneticshield.com)**

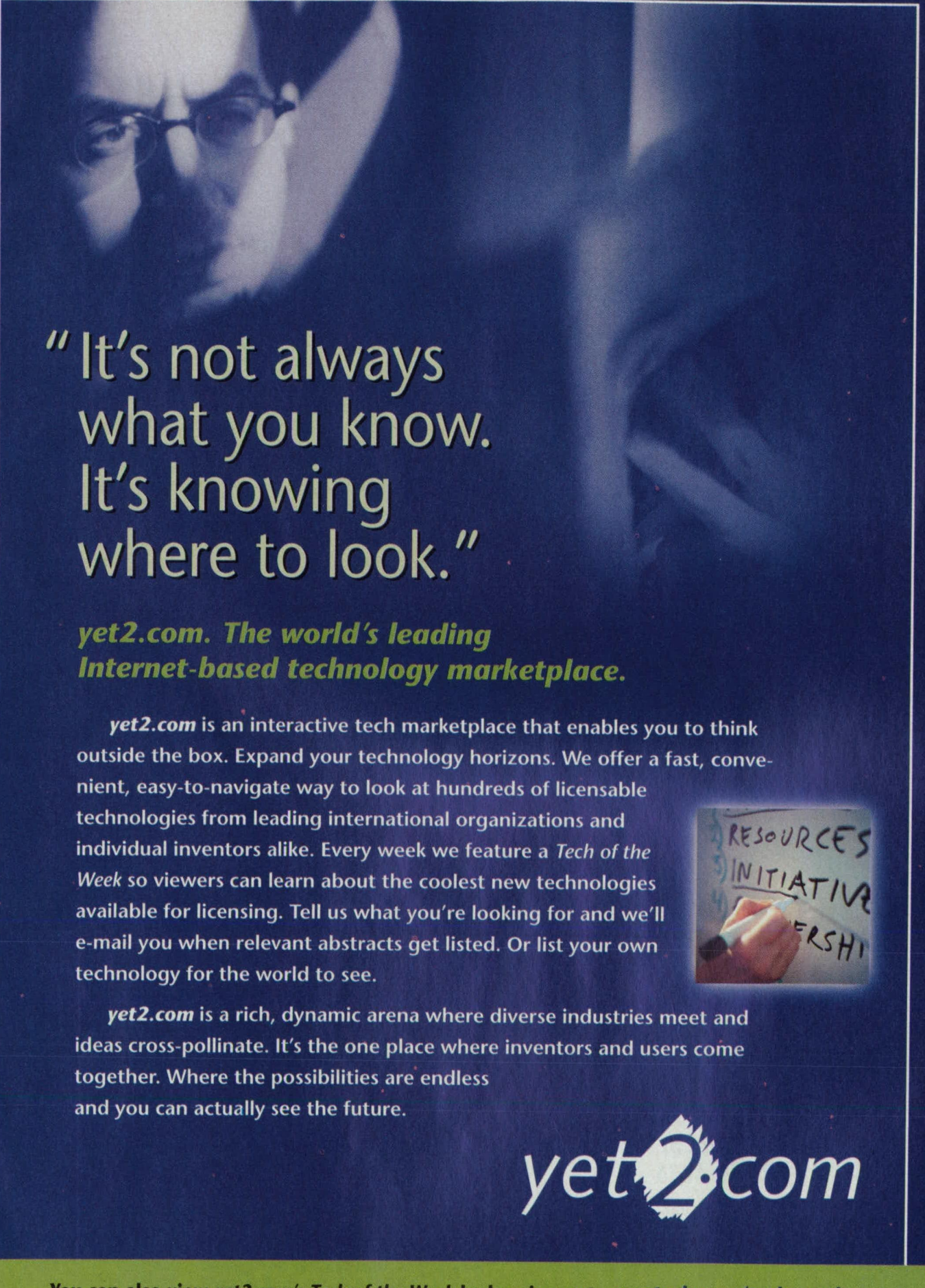
The cylinder is the most perfect shield. Our customers know this ... and they know Electro Magnetic Interference (EMI) problems require custom designs that are not always cylindrical. For sixty years, they have been relying on our knowledgeable engineers to solve EMI problems with shielding designs that fit

tight tolerances or entire buildings.

Visit our web site for "Magnetic Shielding Lab Kit & Catalog Guide"... eliminate EMI in your OEM designs.

**MAGNETIC SHIELD CORP.**  
740 N. Thomas Dr., Bensenville, IL 60106

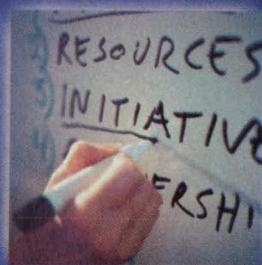




"It's not always  
what you know.  
It's knowing  
where to look."

**yet2.com. The world's leading  
Internet-based technology marketplace.**

yet2.com is an interactive tech marketplace that enables you to think outside the box. Expand your technology horizons. We offer a fast, convenient, easy-to-navigate way to look at hundreds of licensable technologies from leading international organizations and individual inventors alike. Every week we feature a *Tech of the Week* so viewers can learn about the coolest new technologies available for licensing. Tell us what you're looking for and we'll e-mail you when relevant abstracts get listed. Or list your own technology for the world to see.



yet2.com is a rich, dynamic arena where diverse industries meet and ideas cross-pollinate. It's the one place where inventors and users come together. Where the possibilities are endless and you can actually see the future.

yet2.com



gram selects parameter values according to a combinatorial design that generates a near-minimum number of test cases to afford the user-specified coverage. The program is especially suitable for systems having a large number of value combinations in which there is a need for a user-specified degree of coverage in a relatively small test suite. An evaluation on test parameters from the Deep Space One mission revealed that this program generated fewer test cases than did a prior test-case-generator program. The performance of this program is comparable to that of an Internet-based service called AETG. However, unlike AETG, this program uses a purely deterministic algorithm, is amenable to modification by the user, and can be incorporated into other programs.

*This program was written by Yu-Wen Tung, Daniel Dvorak, Eugene Chalfant, and Wafa Aldiwan of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Software category.*

*This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-21195.*

## Software Manages Documentation in a Large Test Facility

The 3MCS computer program assists an instrumentation engineer in performing the 3 essential functions of design, documentation, and configuration management of measurement and control systems in a large test facility — initially, a propulsion-system test facility at Stennis Space Center. By largely automating what were previously manual procedures involving handling of paper documents by disparate personnel, 3MCS helps to reveal and prevent errors while reducing, from days to hours, the time needed to transform test requirements into design documents (including drawings) and work orders. Among the services provided by 3MCS are acceptance of input from multiple engineers and technicians working at multiple locations; standardization of drawings; on-line distribution of the most recent versions of drawings and other documents to all participants; automated cross-referencing, identification of errors, and listing of components and resources; automated downloading of test settings; and provision of information to customers. 3MCS is designed to be executed on personal

computers. It utilizes and depends on some commercially available computer programs, including Windows 98/NT, AutoCAD 2000, Promise, Microsoft Office 2000, and some utility and virus-detection software.

*This program was written by Joseph M. Gurneck of Lockheed Martin for Stennis Space Center.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to the Intellectual Property Manager, Stennis Space Center; (228) 688-1929. Refer to SSC-00122.*

## Software Performs Testing, Monitoring, and Control Functions

The Front End Processor (FEP) Real-Time Embedded Software performs command and data-processing functions for an aeronautical MIL-STD-1553B telemetry link and ground support equipment (GSE) in a spacecraft-equipment-testing environment. The FEP is used in the Test, Control, and Monitor System of the Space Station Program for checking out Space-Station modules and payloads as they flow through Kennedy Space Center. Consisting of about 50,000 lines of C-language code, the FEP software runs on Motorola MVME 167 processors in a VersaModule Eurocard (VME) chassis. The software can be recompiled for execution on other processors. The software interacts with the 1553B telemetry link through commercial VME interface cards and supports as many as four redundant 1553B buses. The GSE interfaces consist of analog, digital, relay, and serial links for controlling the GSE used in testing. The software includes modules that control and monitor the MIL-STD-1553B links of the Space Station and the associated GSE interfaces. Back-end interfaces (user interfaces) to the FEP software are provided through a standard Ethernet network that enables a user or a testing application program to exercise control or to monitor data from the interfaces supported by the FEP software.

*This program was written by Thomas L. Herring, Richard B. Arnold, Christopher S. Forney, Eric J. Schafer, Berta A. Alfonso, Wyck C. Hebert, Jeffrey S. Vickers, Pamela A. Meier, Jose A. Marin, Andrew E. Wheeler, and Chau B. Lee of Kennedy Space Center. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Software category.*

KSC-12122



## SEALING SOLUTIONS

FOR ALL PROCESSING APPLICATIONS

AMERICAN VARISEAL • BUSAK + SHAMBAN • DOWTY ENGINEERED SEALS  
FORSHEDA • PALMER-CHENARD • SILCOFAB • WILLS

- Turcon®, Turcite®, HiMod®, Zurcon®, Luytex®, Orkot® Marine and other high performance materials available
- Designs and materials for wide range of applications

Call: 1-800-767-3257

Fax: 1-303-469-4874

Polymer sealing solutions

2531 Bremer Drive, P.O. Box 176, Fort Wayne, IN 46801

Tel: (219) 748-5703 • Fax: (219) 749-4208

email: [tcallison@tispp.com](mailto:tcallison@tispp.com) • web: [www.polymersealing.com](http://www.polymersealing.com)

A part of Smiths Group plc

**Shamban**  
aerospace sealing systems

Busak+Shamban



November 2001

# PHOTONICS Tech Briefs

PHOTONICS SOLUTIONS FOR THE DESIGN ENGINEER

**The Search for the  
All-Optical Switch**

**New! Technologies  
of the Month**



**New Products —  
see page 30a**

[www.ptbmagazine.com](http://www.ptbmagazine.com)



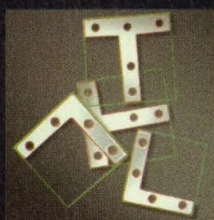
## Don't be fooled by appearances



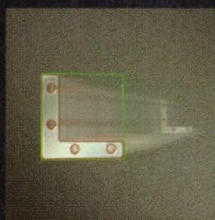
model 1



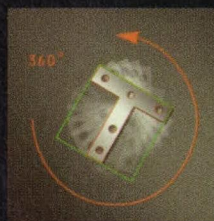
model 2



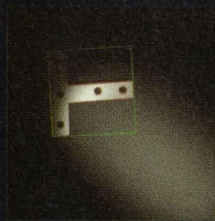
multiple occurrences/models



scale



rotation



lighting

### MIL 7.0's geometric pattern recognition technology finds what you're looking for every time!

Matrox Imaging Library (MIL) introduces Geometric Model Finder, an innovative pattern recognition tool that uses geometric features to quickly find objects with unparalleled levels of accuracy and robustness - under the harshest conditions.

This tool lets you quickly and accurately locate an object - or multiple objects - at any position, including angle, and at any scale from 50-200 percent. Even when working with obstructed objects and non-uniform contrast changes including contrast reversal, MIL 7.0 hits the target model every time. Geometric Model Finder also incorporates a unique method of calibration, which transparently compensates for distortions and gives results in real-world coordinates.

Contact us today and learn how MIL 7.0's Geometric Model Finder can help solve robot guidance, CMP wafer alignment and other challenging applications.

Interested in learning more about MIL 7.0?

Visit [www.matrox.com/imaging/ads/mil7/nt](http://www.matrox.com/imaging/ads/mil7/nt)  
Call 1-800-804-6243 / +1-514-822-6020  
E-mail [imaging.info@matrox.com](mailto:imaging.info@matrox.com)



# PHOTONICS Tech Briefs

Supplement to *NASA Tech Briefs*' November 2001 Issue  
Published by Associated Business Publications Intl.

## Features

2a The Search for the All-Optical Switch

## Tech Briefs

8a Tunable Ultraviolet Light Source for Combustion Experiments

12a Fourier-Transform X-Ray Microscope

14a Wavelength-Agile External-Cavity Diode Laser

16a Thermal Imaging for Diagnosing Fuel Cells

18a Fiber-Optic Illumination for Microscope

19a Enhanced Optical Microresonators for Detecting Molecules

20a System for Measuring Three Tilts and Distance of an Object

22a Improved Etalon-Type Fiber-Optic Hydrogen Sensors

24a Algorithm for Optimizing Designs of Diffractive Optics

25a Computer Program for Designing Diffractive Optics

26a Ring-Resonator/Bragg-Grating Laser-Feedback Elements

## Departments

6a Technologies of the Month

30a New Products

## Editorial Advisory Board

**Bob Breault**, President, Breault Research Organization

**Dr. Geoffrey Burnham**, President, Semiconductor Laser International

**Dr. Jack D. Gaskill**, Professor emeritus of Optics, Optical Sciences Center, University of Arizona

**Dr. Arthur Guenther**, Professor of Electrical Engineering and Physics & Astronomy, Center for High Technology Materials, University of New Mexico

**R. Brian Hooker**, Associate Research Professor, Dept. of Electrical and Computer Engineering, University of Colorado at Boulder

**Heather Tooker**, General Manager, Meadowlark Optics



**On the cover:** *Optronic Laboratory's OL 770-LED CCD-based multichannel spectroradiometer.*

*Cover photo courtesy of Optronic Laboratory Inc.*





## Got an Ultrafast Application? Get a Mai Tai.

### The new, ultrashort pulse Mai Tai:

- **Performance:** <30 fs pulse width; >30 nm bandwidth; >300 mW average power; 800 nm output wavelength.
- **Best by Design:** The unique combination of a Saturable Bragg Reflector (SBR) and negative dispersion mirrors produces ultrashort pulses from a compact cavity. Mode-locking is self-starting and self-sustaining with no pulse drop-outs.

### The popular, tunable Mai Tai:

- **Performance:** Two tuning ranges: 750–850 nm or 780–920 nm; <100 fs pulse width; up to 1 W average power.
- **Best by Design:** Regenerative mode-locking ensures smooth wavelength tuning with no pulse drop-outs. Automated dispersion control guarantees optimized pulse widths over the whole tuning range.



*Both the new short-pulse Mai Tai™ and the tunable Mai Tai are briefcase-sized, rugged, ultrafast Ti:sapphire laser systems. Both are completely controlled from your PC through a user-friendly graphical software interface for hands-free operation. And both are **available now**. Call today.*

*Ultrashort pulses or ultrawide tuning—nothing beats a Mai Tai.*



The Solid State Laser Company™

Call: 1-800-SPL-LASER (775-5273) Web: <http://www.spectra-physics.com> E-mail: [sales@splasers.com](mailto:sales@splasers.com)

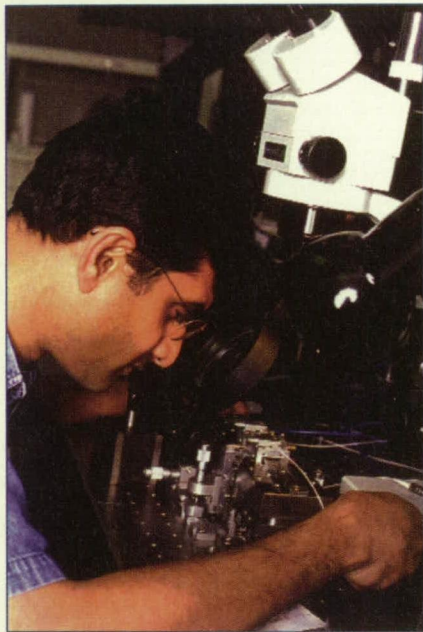
© 2000 Spectra-Physics Lasers



# The Search for the All-Optical Switch

As the demand for bandwidth grows, the industry races to find better and faster switching and other technologies.

It is a peculiar moment in the life of fiber optic technologies related to communications. Potential customers face a glut of bandwidth for the current traffic, but no one doubts that demand will someday catch up with supply, as Internet telephony and web use, computer-to-computer communications, streaming digital video and audio, and other services grow in volume. According to sources at Corning Inc., demand for bandwidth is expected to grow at an average rate of more than 100 percent per year for the next 10 to 15 years.



Radiant Photonics' optics lab

But with so much existing fiber optic cabling, new instrumentation is required to get that cabling to yield increased bandwidth. Most of the existing system uses optical fiber for long-distance transmission, but the light signals must be converted to electrical signals for switching and amplification. This process is costly, and limits the bandwidth the systems can carry. So the industry is searching for technologies that can do away with the electrical repeaters and meet bandwidth demands with all-optical systems.

One approach to the problem is wavelength division multiplexing (WDM), by which multiple optical signals are transmitted on a single fiber strand. This process has increased the amount of information carried on a fiber from between 1 and 2.5 gigabits per second

(Gb/s) to between 10 and 40 Gb/s, the latter capacity just now reaching the newest installations. Researchers are also working on 400 Gb/s carriers.

But carriers cannot realize these gains with the existing electrical equipment that routes signals. Existing switches cannot deal with throughput above 2.5 Gb/s. So many companies in the industry are striving to be the first to develop an all-optical-core switch that can route signals without the assistance of electrical switches.

One source of funds for such development is the Ballistic Missile Defense Office (BMDO) and its Small Business Innovation Research department (SBIR). This agency's interest is in battlefield communications, where data is collected, interpreted, and communicated to various military systems, enabling complex battle management decision-making. Synchronization between multiple and sometimes distant ground and air subsystems is required, and response times must be the fastest possible.

Several companies are building solid-state optical-core photonic switches that do not rely on an electrical impulse, changing a signal's direction based on its wavelength or polarization. Radiant Photonics of Austin, TX, has developed a model switch that is insensitive to polarization differences or slight variations of wavelength in incoming signals, thereby eliminating costly correcting equipment. It is based on polymers used in thermo- or electro-optic prisms. These prisms can vary the index of refraction in response to temperature or an input voltage. The device determines where a signal hits a diffraction grating, and thus controls which output fibers the signal will reach. Doping the gelatin used in the prisms gives them their refractive characteristics. Radiant's switch can operate equally well in the C, L, and S communications bands, and provides response speeds of just 1 nanosecond (compared with 10-15 milliseconds for competing technologies), and has an insertion loss of less than 1 decibel.

Other companies are developing polymer switches, too, but most rely on complicated phase delays, and are thus sensitive to polarization differences and wavelength variations. Radiant's switch would do without more expensive lasers and correcting equipment. It also would

have faster response times than micro-mechanical switches, also under development. It could have as many as 50 output channels. BMDO funded the work because it needed a polymer for high-speed fiber optic components that could withstand the temperatures of airborne and spaceborne applications.

Meanwhile, SpectraSwitch Inc. of Santa Rosa, CA, has patent-pending technology for using liquid crystal as the switching medium. Its WaveWalker™ components include a low-port-count photonic switch called the WaveWalker 1 × 2, used in single-mode transmission in an all-optical network. The company's switch uses liquid crystal and birefringence — the ability to refract unpolarized light into two separate orthogonally polarized rays — with the material's response to an electric field. A liquid crystal cell rotates the polarization of incoming light when a voltage is applied. SpectraSwitch's device is one of the fastest-switching under development, reducing the current optomechanical industry standard from 10-15 milliseconds to less than 4. Because the material is rugged and immune to vibration degradation, the company claims it will have a billion-cycle durability. SpectraSwitch expects to develop a full line of WaveWalker components, including variable optical attenuators, optical add/drop multiplexers, polarization mode dispersion compensators, and multifunctional modules. The technology was funded in part by BMDO.

Another company using liquid crystal technology is Chorum Technologies of Richardson, TX. The company has developed its PolarWave commercial line from its technology, consisting of a fast add/drop switch and a 1 × 2 switch. The devices use a patented fault-tolerant architecture to achieve crosstalk and insertion loss numbers comparable to the optomechanical specifications now in use. The switch is suited to network protection and restoration applications that require highly reliable switching with response times in the millisecond domain.

Chorum's switch uses polarization manipulation to provide the basis for switching with no moving parts. Its complementary polarization design allows for a high polarization extinction ratio made possible by the use of liquid crystal. And a method for eliminating unwanted optical energy yields a crosstalk



**OLYMPUS OEM**

# THE BEST PARTS OF US BELONG WITH YOU.

Olympian standards.

That's what we demand of every Olympus product.

For example: the superior optical performance of the Infinity Corrected Optics; the tested and proven high resolution; the contrast that's in stark contrast to all others; the long working distance objectives that make objective comparisons near impossible.

Yes, there's so much Olympus OEM Components can offer you.

UIS objectives and microscope systems. Clean room compatible revolving nosepieces. Illumination and motorized components. Observation tubes and lamphousings. Video and digital camera adapters. Auto focus units.

And so much more.

**All tried.**

**All true.**

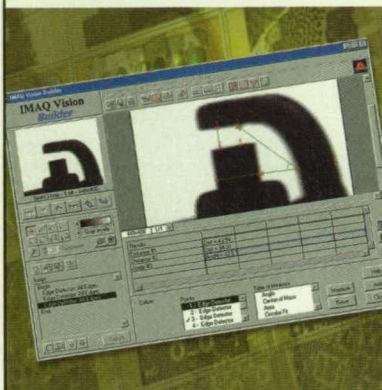
**All Olympian.**

**OLYMPUS®**  
FOCUS ON LIFE

For more information about Olympus OEM Components, visit our Web site @ [Olympusamerica.com](http://Olympusamerica.com) or call 1-800-446-5967



# Accelerate Your Vision Development

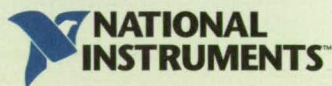


Quickly develop machine vision and scientific imaging solutions with the latest IMAQ™ Vision Builder.

- Integration of your vision application with motion and data acquisition
- Easy-to-use, configurable development environment
- Ability to create LabVIEW™ VIs and Measurement Studio™ code recipes
- Complete set of machine vision and imaging functions
- Vision Solution Wizard

**ni.com/info**

To learn more about IMAQ Vision Builder, visit [ni.com/info](http://ni.com/info) and enter na9n28.



**(800) 811-2046**

Fax: (512) 683-9300 • [info@ni.com](mailto:info@ni.com)

© Copyright 2001 National Instruments Corporation. All rights reserved. Product and company names listed are trademarks or trade names of their respective companies.

figure of less than -45 dB and an insertion loss of less than 1.3 dB. The PolarWave line will also include optical filters, optical processors, and integrated optical subsystems. BMDO awarded Chorum an SBIR Phase II contract to develop a state-of-the-art switch for its optical signal processing applications.

OptiComp Corp. of Zephyr Cross, NV, has developed an optoelectronic logic-array-based distributed crossbar switch that provides terabit-level end-to-end throughput. This SmartCross™ crossbar switch can be integrated into networks of all kinds that use the 1.3-micron wavelength standard, reducing central switching requirements in datacom and telecom networks. The distributed crossbar supports high levels of fan-in and fan-out switching. The company plans a range of components and subsystems using the crossbar technology, targeted for integration into long- and short-distance networks. Specifications for beta-site testing have been solicited from industrial partners. BMDO funds supported the production of cost-effective 1.3-micron VCSELs for massive parallel optical interconnects.

At another California company, Templex Technologies of San Jose, an optical encoding and decoding technology based on fiber Bragg gratings has been developed that would increase the optical throughput in a metro-access network and minimize the need for costly routing equipment. The company expects a hundredfold increase in the efficiency and capacity of today's networks. Called SmartFBG™, the product is aimed at the market for ultra-narrow channel-spacing dense wavelength division multiplexing. Templex bases its expectations on a passive all-optical routing and switching protocol using complex gratings about the size of a microscope slide.

The gratings are formed by producing complex periodic variations in the index of refraction of the glass lengthwise along a fiber. The grating is designed so that the refractive index modulation causes light of a specific wavelength. This makes it useful for separating and switching signals, and also for putting an optical code on every pulse of light. When a short pulse is reflected by the grating, the light is reshaped, delayed, and stretched into a uniquely coded pulse. The temporal shape of this optical signal can then be used for multiplexing and demultiplexing information, thereby eliminating electronic conversion. Templex's optical code division multiplexing is the only coding technology that is full compatible with dense wavelength division multiplexing. BMDO supported Templex with a

two-year FasTrack Phase II SBIR contract to pursue novel switching and control devices for all-optical networking.

Yet another California company, BroaData Communications of Torrance, is marketing a series of duplex multimedia extenders using a crossbar technology that allows simultaneous transmission of audio, video, and data content along one fiber. The optoelectronic crossbar combines signal fan-out and fan-in operations with electronic modulation of laser sources. It comprises three plane modules that can be stacked on each other to



Corning Applied Technologies' polarization controller

produce a very compact device. The crossbars, with switching speeds ranging from 0.1 to 30 microseconds, are compatible with fiber optic communications standards. Other applications include high-speed signal switching, reconfigurable networks, and signal multiplexing. BMDO's SBIR program underwrote this technology to provide fast, reconfigurable networks and to improve computer communication systems.

## Get connected with the companies mentioned in this article.

Radiant Photonics  
(512) 339-0500  
[www.radiantphotonics.com](http://www.radiantphotonics.com)

SpectraSwitch Inc.  
(707) 568-7000  
[www.spectraswitch.com](http://www.spectraswitch.com)

Chorum Technologies Inc.  
(214) 570-3509  
[www.chorumtech.com](http://www.chorumtech.com)

OptiComp Corp.  
(775) 588-4176  
[www.opticomp.com](http://www.opticomp.com)

Templex Technology Corp.  
(408) 573-0691  
[www.templex.com](http://www.templex.com)

BroaData Communications Inc.  
(800) 214-0222  
[www.broadacom.com](http://www.broadacom.com)

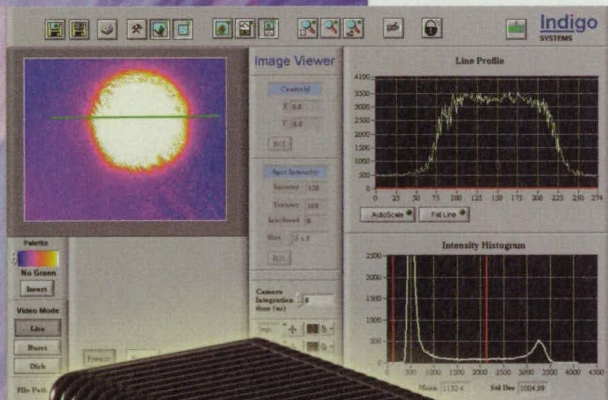


# System Solutions for Optical Telecommunications Detection



## ISC0007-GX 512x1 InGaAs Detector Array

- Designed specifically for DSP-based architectures, the ISC0007-GX is the optical co-processor for advanced OPM/OSA applications
- Programmable features interact with the OPM's DSP to provide higher performance, greater accuracy, and better value
- Capable of measurements over 60dB dynamic range



## Alpha NIR ultra-small InGaAs camera

- Highly sensitive to near- and shortwave-infrared wavebands from 900-1700 nm
- Ideal for detection of telecommunications laser radiation, especially in the S, C, and L DWDM wavebands
- The Alpha NIR kit includes a digital frame grabber and a complete data acquisition and analysis software package



**indigo**  
brighter.

[www.indigosystems.com](http://www.indigosystems.com)

5385 Hollister Ave. #103 • Santa Barbara, CA 93111 • Tel. 805-964-9797 • Fax 805-964-7708



# Technologies of the Month

Sponsored by **yet2.com**

For more information on these and other new, licensable inventions, visit [www.nasatech.com/techsearch](http://www.nasatech.com/techsearch)

## Optical Acceleration Sensor for Highly Sensitive Acceleration and Vibration Measurement

An acceleration measurement system on an optical basis is presented. Low weight, high sensitivity, and excellent EMC compatibility are its primary properties. The sensor is highly sensitive due to its particular micromechanical design. Multiple sensors can be arranged on a single sensor line, and their signals can be discriminated. An excellent EMC/ESD compatibility is provided since no metallic parts are involved, either in the sensor or in the transmission line. Moreover, the fiber optic technology allows highly insulated measurement. Multiple acceleration measurement and vibration detection are the preferred applications.

This invention presents a new type of Bragg grating acceleration and vibration sensor. A micromechanical structure allows acceleration measurements with lower inert mass than known Bragg acceleration sensors. The high sensitivity of the sensor is achieved by a compact mechanical lever in the structure. An inert mass is attached to the lever that moves in the plane of the structure. When accelerated, the lever stretches a fiber grating. Two overlapping gratings move in opposite directions, which results in an intensity modulation of back-re-

flected light with excellent temperature compensation and a high sensitivity. By means of different wavelengths several sensors can interrogate on one optical fiber line.

For more information go to

[www.yet2.com/PSUser/special.htm?c=1240&l=51&cid=27815](http://www.yet2.com/PSUser/special.htm?c=1240&l=51&cid=27815)

## Laser Sensor for Weld Seam Tracking

The laser vision sensor is a modern noncontact weld seam tracking system. The sensor uses a visible (red) laser to illuminate the weld joint. The laser is viewed through a very narrow-band optical filter by a high-resolution CCD camera. The filter removes any light not at the laser frequency, including any arc light. The system is completely unaffected by the welding arc as long as the arc is not directly in the sensor's field of view. In practical terms, the sensor looks ahead of the arc a short distance. The video signal is digitized in the sensor and sent to the vision controller. Suitable corrections are output to the slides.

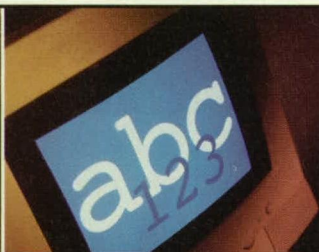
The laser vision sensor is to track weld lines for adaptive gas metal arc welding and submerged arc welding. The specific application is circumferential multipass/multilayer girth welding and longitudinal welding.

For more information go to

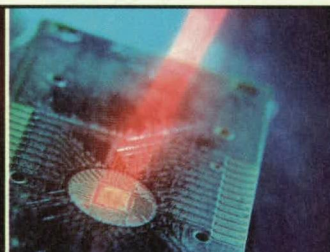
[www.yet2.com/PSUser/special.htm?c=1240&l=50&cid=27815](http://www.yet2.com/PSUser/special.htm?c=1240&l=50&cid=27815)



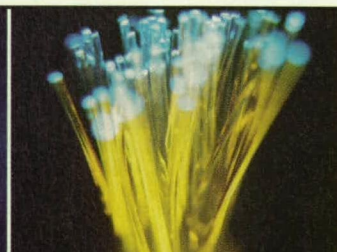
PHOTOMETRY / RADIOMETRY



COLORIMETRY



POSITION SENSING



FIBER OPTICS

## UDT. A Quarter Century Of Light Measurement Solutions.

For over 25 years, UDT has dominated the light measurement industry—specializing in test instrumentation for Photometry, Radiometry, Fiber Optics, Position Sensing and Colorimetry.

Perhaps UDT's success is based on its full line of versatile benchtop and handheld meters. Featuring interchangeable sensors and integrating spheres, and covering the UV to near-IR range.

Or UDT's state-of-the-art NIST traceable calibration facility, ensuring the highest levels of measurement accuracy.

Or UDT's technical expertise and outstanding service, providing you with the "can-do" customer support you demand.

Whatever the reason, UDT is ready to make your light measurement a total success.

For more information, call 1-800-891-2709. Or visit us at <http://www.udtinstruments.com>.

**UDT INSTRUMENTS**

727 S. Wolfe St., Baltimore, MD 21231 (800) 891-2709 Fax (410) 342-7028 Web: [www.udtinstruments.com](http://www.udtinstruments.com)





Wavelength Measurement of Violet Laser using Coherent WaveMaster



# No "Shrinking Violet"

## New Longer Lifetime Violet Lasers

GENOMICS

PRINTING

CYTOMETRY

OPTICAL  
STORAGE

DISPLAYS

CONFOCAL  
MICROSCOPY

- 4 mW and >25 mW versions
- Longer lifetime InGaN laser diodes
- Superior beam quality
- User adjustable focus
- TE cooled for excellent wavelength stability
- CE marked standard HeNe size package
- Single transverse mode
- OEM versions available
- Longer wavelengths available

When it comes to violet laser systems, Coherent is the world leader. We combine the very latest Indium Gallium Nitride semiconductor laser technology available with our high quality optics and drive electronics to give you, our customer, a truly superior violet laser system.

Coherent's 30 years experience as the world leader in laser systems gives you the very best laser available for your application. We back our laser diode modules and systems with a one year warranty and a level of service and technical support that is second to none.

For a copy of our latest data sheets describing the new range of Violet Laser Diodes or to discuss your OEM application, please call 1-800-343-4912.

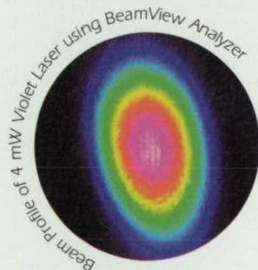


**NEW**

Longer Lifetime  
MTTF >10,000 hrs

Extended  
1 year  
warranty

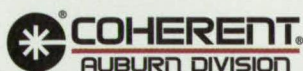
4 mW Violet Laser System



Beam Profile of 4 mW Violet Laser using BeamView Analyzer



African Violet



A Member of Coherent Photonics Group

2303 Lindbergh Street  
Auburn, CA 95602  
Toll Free: 1-800-343-4912  
Tel: (530) 889-5365  
Fax: (530) 889-5366

<http://catalog.CoherentInc.com/lv.html>

**UK** Free Phone: 0800 515801  
**Germany** +49-6071-968-303  
**France** +33-1-60 19 40 40  
**Japan** +81 (0) 3 5635 8680



# Tunable Ultraviolet Light Source for Combustion Experiments

The source enables simultaneous WMS and LIF measurements for quantitation of trace gas species.

John H. Glenn Research Center, Cleveland, Ohio

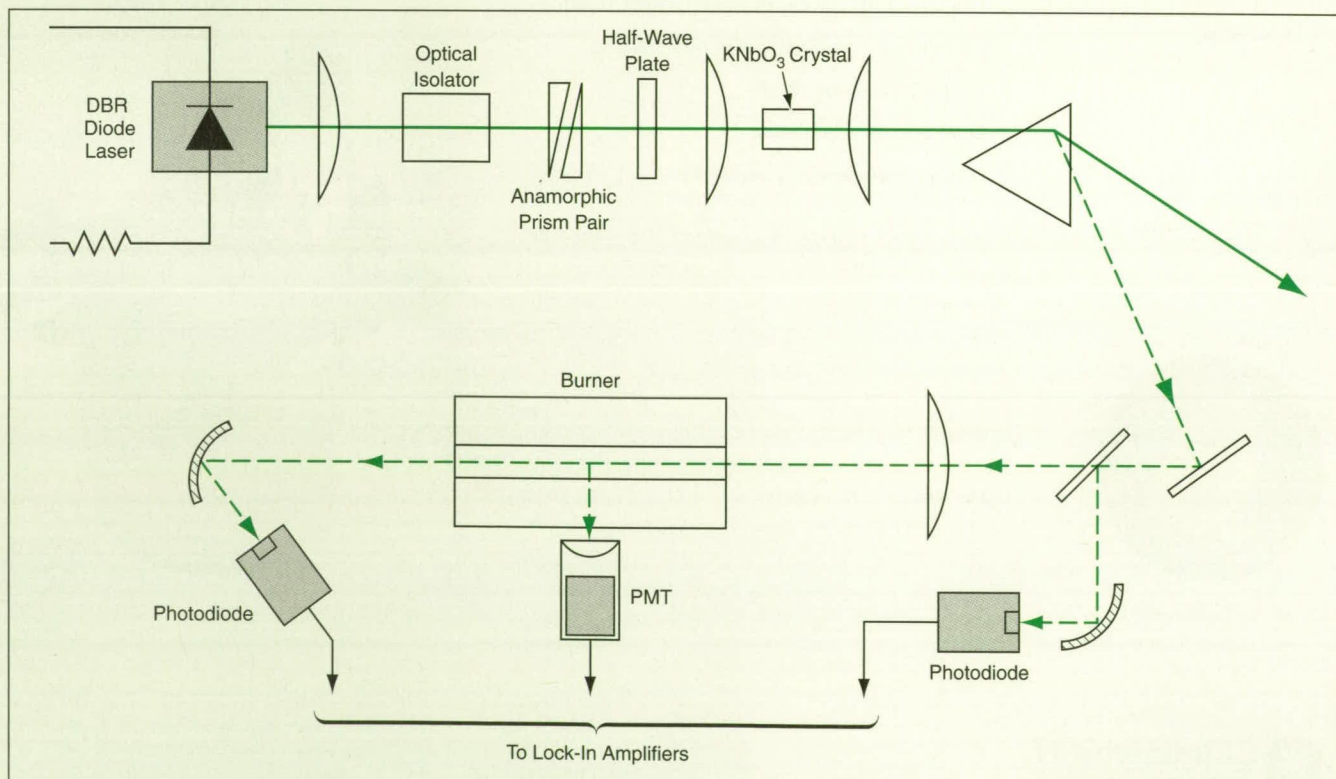
An ultraviolet light source that comprises a tunable diode laser and associated optics provides the optical excitation needed for simultaneous wavelength-modulation-absorption spectroscopy (WMS) and laser-induced-fluorescence (LIF) measurements in experiments on combustion. These measurements are needed for determining the spatially and temporally resolved concentrations of molecular and radical species that play important roles in flames. Other uses for measurements of this type could include general detection and quantitation of trace gases in the atmosphere, including toxic gases emitted by industrial facilities. Instruments that incorporate light sources like the present one and that will perform these measurements are undergoing development. In comparison with prior ultraviolet lasers and with prior WMS and LIF instruments, the present light source and the developmental instruments are compact and rugged and consume less power. As a result, the developmental instruments are expected to be suitable for use, not only in laboratories, but also in diverse harsh environments, including those of drop towers, aircraft, and spacecraft.

Heretofore, WMS and LIF measurements have been performed separately. WMS enables highly sensitive detection and quantitation of trace molecular and radical species. However, because it involves integrated absorbance along a laser beam, it yields no information on the spatial distribution of species. LIF measurements taken along lines of sight perpendicular to a laser beam can be used to map relative densities of species as functions of position along the line of sight. However, it is extremely difficult to obtain absolute density information from LIF data because of a need for careful calibration of laser intensity and geometric factors and mathematical modeling of fluorescence quenching by collision partners. By suitable processing of WMS and LIF data acquired simultaneously by the developmental instruments, it should be possible to eliminate the difficulties associated with geometric factors and laser-intensity fluctuations, thereby facilitating the determination of absolute density distributions.

The figure is a simplified schematic depiction of the present light source as part of a prototype apparatus for prob-

ing a hydrocarbon flame with simultaneous WMS and LIF measurements in a wavelength band centered about 426 nm. This wavelength band is associated with CH radicals, which play a major role in combustion of hydrocarbons. Pump light at a wavelength of  $\approx 852$  nm, with a power of  $\approx 120$  mW, is generated by a distributed-Bragg-reflector (DBR) diode laser. The laser beam is collimated and circularized by an anamorphic prism pair and focused into a 7-mm-long A-cut  $\text{KNbO}_3$  crystal, which is optically nonlinear and thus serves to convert some of the laser power to the second harmonic, which is at the desired wavelength of  $\approx 426$  nm. An optical isolator between the diode laser and the frequency-doubling  $\text{KNbO}_3$  crystal minimizes feedback of reflected light to the laser diode. A half-wave plate, also between the diode laser and the  $\text{KNbO}_3$  crystal, matches the polarization of the pump beam with the orientation of the crystal.

The  $\text{KNbO}_3$  crystal is mounted on a thermoelectric cooler in an  $\text{N}_2$ -purged housing for temperature-tuned noncritical phase-matching operation at a temperature near  $10^\circ\text{C}$ . The 426-nm beam

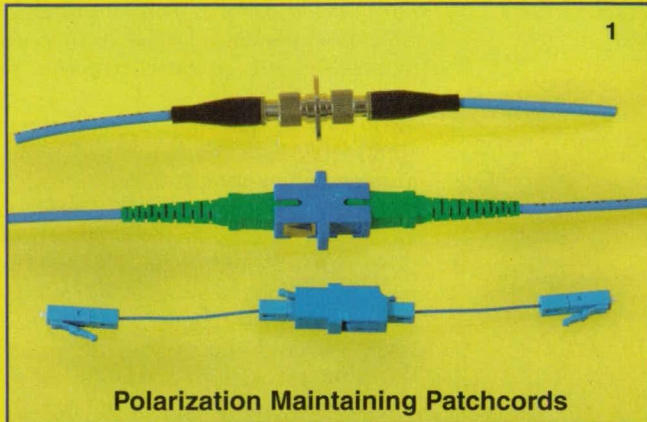


The Tunable Ultraviolet Light Source has been incorporated into a laboratory apparatus used to demonstrate the feasibility of simultaneous WMS and LIF measurements to determine distributions of CH radicals along a line defined by a laser beam.





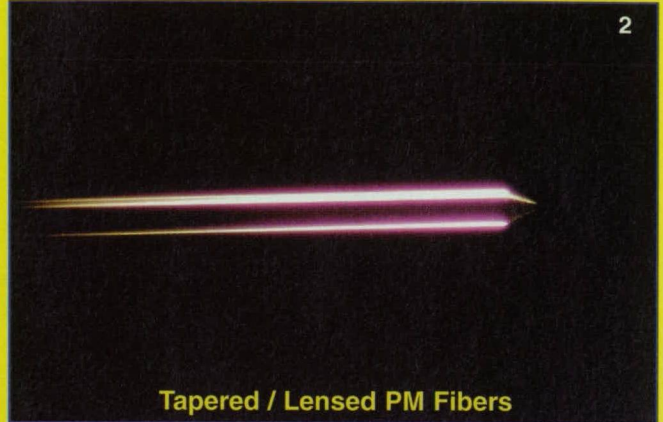
# POLARIZATION MAINTAINING FIBER PATCHCORDS



1

**Polarization Maintaining Patchcords**

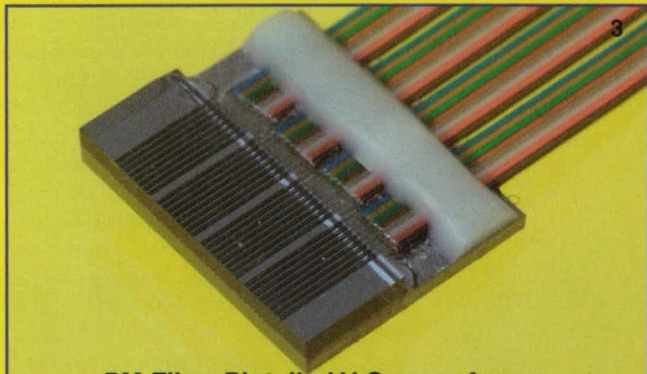
Up To 30dB Polarization Extinction Ratios  
Typical Insertion Loss <0.3dB, Up To 60dB Backreflection  
Super, Ultra, Angled FC/PC, SC, AT&T-ST, LC



2

**Tapered / Lensed PM Fibers**

Improved Coupling To And From Waveguides, Diodes  
Customer Specific Designs  
Metalized Fiber Versions



3

**PM Fiber Pigtailed V-Groove Arrays  
Silicon Optical Benches**

Up To 40 Fiber Arrays  
250 Or 400 Micron Spacing  
Customer Specific Designs



4

**Hermetically Sealable PM Patchcords with Metal Solder**

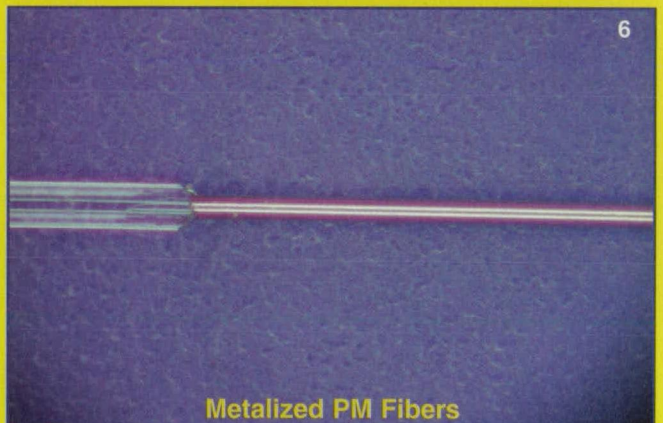
Meets Telecordia Specifications  
Customer Specific Designs  
Used in packaging Optoelectronic Devices



5

**Hermetically Sealable PM Patchcords with Glass Solder**

Meets Telecordia Specifications  
Customer Specific Designs  
Used in packaging Optoelectronic Devices



6

**Metalized PM Fibers**

Cleaved Ends, Masked Regions  
Ideal For Component Packaging  
Customer Specific Designs

OZ OPTICS LTD., 219 Westbrook Rd, Carp, ON, CANADA, K0A 1L0 Phone: 613-831-0981  
Toll Free Phone: 800-361-5415 Fax: 613-836-5089 Email: sales@ozoptics.com  
[www.ozoptics.com](http://www.ozoptics.com)





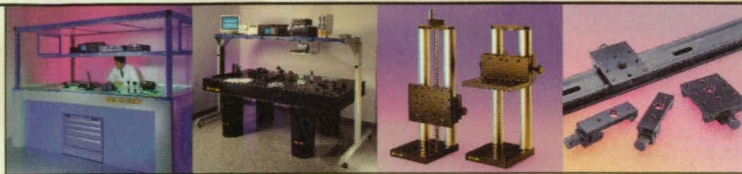
**MELLES GRIOT**

Create

Transform

Detect

# Equip Your Laboratory



Melles Griot carries a full line of equipment and components to enhance the functionality of your research or production laboratory.

## Enclosures for Optical Tables

- Protect tables from being bumped
- Utilize unused space above and below table with optional shelves and cabinets
- Fit both inch and metric tables

## Mobile Instrument Shelves

- Provide eye-level mounting surfaces for instruments and accessories
- Can be placed anywhere over the table
- Provide electrical outlets along both sides of shelf

## Heavy-Duty Vertical Carriers

- Mount and position heavy instruments
- Attach to inch or metric table tops
- Provide high-resolution positioning with optional leadscrew

## Optical Rail Systems

- Ideal for aligning consecutive optical components
- Come in a wide variety of lengths and widths
- Available with inch or metric mounting threads

## The Practical Application of Light

Find Out More:

1-800-835-2626

[www.mellesgriot.com/mg353.htm](http://www.mellesgriot.com/mg353.htm)**MELLES GRIOT**

## Photonics Components

16542 Millikan Avenue • Irvine, CA 92606 • 1-800-835-2626  
(949) 261-5600 • FAX (949) 261-7790 • E-mail: [sales@irvine.mellesgriot.com](mailto:sales@irvine.mellesgriot.com)

Asia +81 (03) 3407-3614 Europe +31 (0316) 333041

[www.mellesgriot.com](http://www.mellesgriot.com)

is collimated and separated from the residual 852-nm pump beam by use of a  $\text{CaF}_2$  prism. The frequency of the residual pump beam is monitored to within  $0.01 \text{ cm}^{-1}$  by use of a scanning interferometer. When the 852-nm power input to the crystal is 85 mW, the 426-nm output power is 100  $\mu\text{W}$ . This output ultraviolet power is stable as long as the temperature of the crystal is stabilized to within  $\pm 0.1^\circ\text{C}$ .

The wavelength of the beam generated by the laser diode is tuned by adjustment of its temperature and injection current. The injection current is modulated at a frequency of 50 kHz to produce wavelength modulation of the frequency-doubled beam. A linear current sweep is also applied to the diode laser, to tune the center frequency across the absorption spectral line of interest during wavelength modulation.

For laboratory feasibility measurements, the 426-nm beam is directed along the flame front of a slot burner. For the purpose of WMS, the intensity of the beam after transmission through the flame is monitored with a silicon positive/intrinsic/negative (PIN) photodiode, the output of which is sent to a lock-in amplifier for detection at a frequency of 100 kHz. A blue-pass filter (not shown in the figure) in front of the photodiode reduces the incident visible and near-infrared flame luminescence. Second-harmonic CH absorption spectra are acquired by detection of the transmitted beam while the frequency is repetitively swept across the absorption spectral line. The second-harmonic signals are calibrated against direct (unmodulated) absorbance measurements.

For LIF measurements, a lens images a 2-mm segment of the region illuminated by the laser beam onto a photomultiplier tube (PMT). A  $431 \pm 1\text{-nm}$  band-pass filter suppresses flame-luminescence light while passing CH-fluorescence light to the photomultiplier. The output of the photomultiplier is sent to a lock-in amplifier for phase-sensitive detection of LIF at a sampling frequency of 100 kHz. (Additional experimental details and measurement results are found in K. A. Peterson and D. B. Oh, *Optics Letters*, vol 24, pp 667-669.)

*This work was done by Daniel B. Oh and Kristen A. Peterson of Southwest Sciences, Inc., for Glenn Research Center.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17120.*



# This is about the only kind of coating we don't make.



## Standard and Custom Coatings. R&D. OEM. Sheet Stock.

With so many capabilities, we never have to sugar coat the truth about our coatings. From custom R&D development to OEM production, ZC&R has exactly what you're looking for. Providing, of course, you're looking for quality. To say nothing of our flexibility in helping design an optimal coating for your project, from micro optics to 29" diameter. To get a real taste of what we can do for you, call 800-426-2864 or visit [zcrcoatings.com](http://zcrcoatings.com) today.

[zcrcoatings.com](http://zcrcoatings.com)



ISO 9002 • AS 9000  
Registered

1401 Abalone Ave. / Torrance, CA 90501 / 310-381-3060 / 800-426-2864 / FAX: 310-782-9951  
e-mail: [info@zcrcoatings.com](mailto:info@zcrcoatings.com) / [www.zcrcoatings.com](http://www.zcrcoatings.com)



# Fourier-Transform X-Ray Microscope

High-resolution maps of chemical-element abundances and chemical bonds could be generated.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed x-ray instrument — a Fourier-transform x-ray microscope — would enable high-resolution imaging of objects with sizes of the order of 20 nm. (This size range is typical of cell organelles.) The instrument would also offer a spectroscopic capability for the sensitive detection and identification of selected chemical elements and chemical bonds. The instrument could be used, for example, to examine microscopic biological samples, to study surface chemistries, or to identify chemical contaminants on the surfaces of micro-electronic devices during fabrication.

Heretofore, information of the sort that the proposed instrument would provide has been obtained through (1) imaging of photoelectrons excited by illumination with a monochromatic beam of soft x-rays from a synchrotron x-ray source or (2) transmission microscopy with monochromatic radiation, also from a synchrotron source. The disadvantage of both techniques is that a large apparatus (a synchrotron) is needed to produce sufficient fluxes at the wavelengths of interest. The

Fourier-transform function of the proposed instrument would exert an effect equivalent to multiplying the flux density of x-rays by a factor of the order of 10<sup>3</sup>; this effect would make it possible to use a smaller, electron-beam-based x-ray source. Consequently, unlike x-ray imaging systems based on synchrotron sources, the proposed system would be amenable to miniaturization.

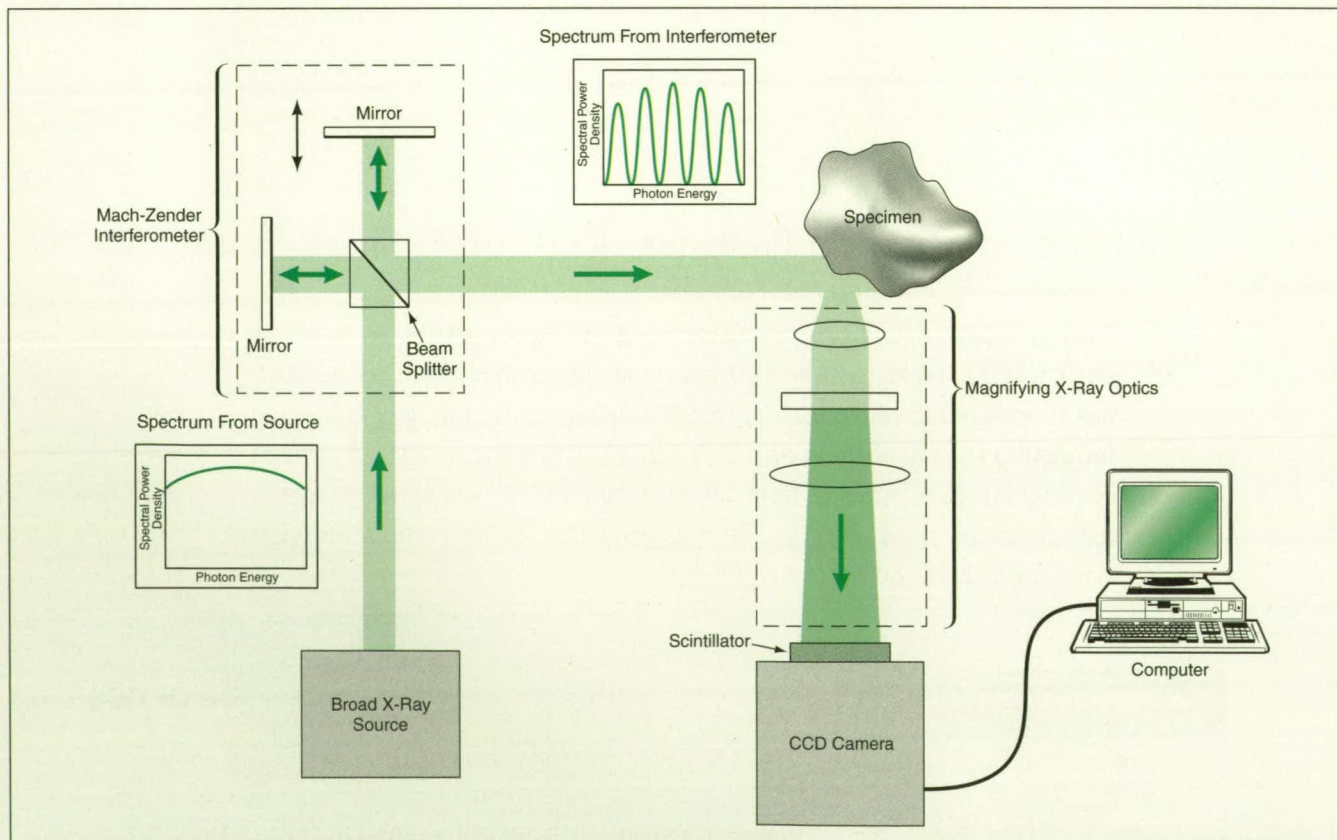
The proposed instrument (see figure) would include an electron-beam-based x-ray source with an output spectrum spanning a wavelength band (1) approximately centered at an absorption edge of a chemical element of interest and (2) broad enough to include possible chemical shifts ( $\pm$  about 10 eV). Two examples of such a wavelength band are  $284.3 \pm 10$  eV for C or  $346.2 \pm 10$  eV for Ca.

A Mach-Zender interferometer would modulate the spectrum with a period of about  $2\pi\Delta x/c$  in frequency (where  $\Delta x$  is the difference between the lengths of the two optical paths in the interferometer and  $c$  is the speed of light). By use of a microactuator, the

mirrors in the interferometer would be moved to vary  $\Delta x$  by small increments. A specimen would be illuminated by the x-ray beam coming out of the interferometer. X rays reflected from the specimen would be imaged on a scintillator, which would convert the x-ray image to a visible one that, in turn, would be acquired by a charge-coupled-device (CCD) camera.

An image would be acquired at each  $\Delta x$ . The image data acquired over all of the many small increments of  $\Delta x$  would be Fourier-transformed and otherwise processed to obtain x-ray spectra for the pixels in the image. From the magnitudes and shifts of absorption edges in these spectra, high-resolution atomic-concentration and chemical-bonding maps of the chemical element of interest could be generated.

This work was done by Kirill Shcheglov and Victor White of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category. NPO-20750

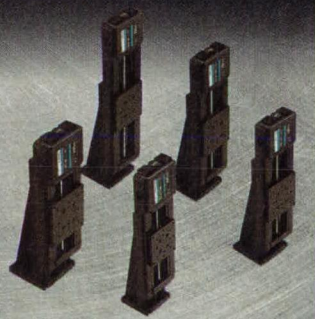


The Fourier-Transform X-Ray Microscope would be a sensitive apparatus for imaging of the concentration and bonding arrangements of a selected chemical element on the surface of a specimen.



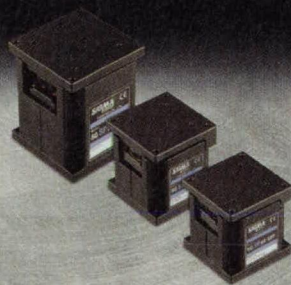
# Step Up To OptoSigma

Precision Motorized Stages.



## Motorized Stages.

OptoSigma introduces X,Y,Z motorized linear stages and rotational stages meeting the performance standards of today's high precision driven market.



## Low Profile, High Accuracy.

Stages facilitate load capacity up to 50kg and accommodate travel from 20mm - 1500mm. These precision driven stages are available with DC Stepping Motor and AC Servo Motor.



## Custom Design Assembly.

At OptoSigma headquarters in Santa Ana, CA, our highly trained engineering staff is available to provide project specific assembly as an alternative to the standard catalog motorized stages.



## Wide Selection.

High accuracy, low profile and broad selection at considerable savings over competitor pricing.

**Contact  
OptoSigma Customer Service  
For A Catalog Today!**

 **OptoSigma®**  
Optics • Opto-Mechanics • Motorized Products  
a Sigma Koki Company

TEL: 949.851.5881 • FAX: 949.851.5058  
2001 Deere Avenue • Santa Ana, CA 92705  
E-MAIL: [sales@optosigma.com](mailto:sales@optosigma.com) • WEB CATALOG: [www.optosigma.com](http://www.optosigma.com)

USA Distributor for:





## Wavelength-Agile External-Cavity Diode Laser

Both stability and wavelength agility are attainable at relatively low cost.

John H. Glenn Research Center, Cleveland, Ohio

A prototype wavelength-agile external-cavity diode laser (ECDL) was demonstrated in the first phase of a continuing effort to develop noninvasive laser-based instruments that would measure absolute concentrations of trace gases. As envisioned, these instruments would offer a combination of high sensitivity, versatility, large bandwidth, long-term stability, accuracy, and reliability — attributes that would make them attractive for use in research on combustion.

The measurement principle to be implemented in the developmental instruments is that of wavelength-modulation spectroscopy (WMS). ECDLs are useful for detecting trace gases by WMS because their wavelength-tuning ranges are greater than those of diode lasers alone and, consequently, it is generally practical to design and operate an ECDL such that an absorption spectral feature characteristic of a molecular species that one seeks to detect lies within the nominal tuning range of the ECDL. In prior ECDLs, wavelength modulation is effected by using piezoelectric actuators to translate laser optics. This mechanical-translation approach limits achievable modulation frequencies to a few kilohertz, whereas frequencies of tens or even hundreds of kilohertz are needed to enable the use of high-sensitivity detection techniques in WMS. In addition, prior commercially available ECDLs include complex and expensive optical components.

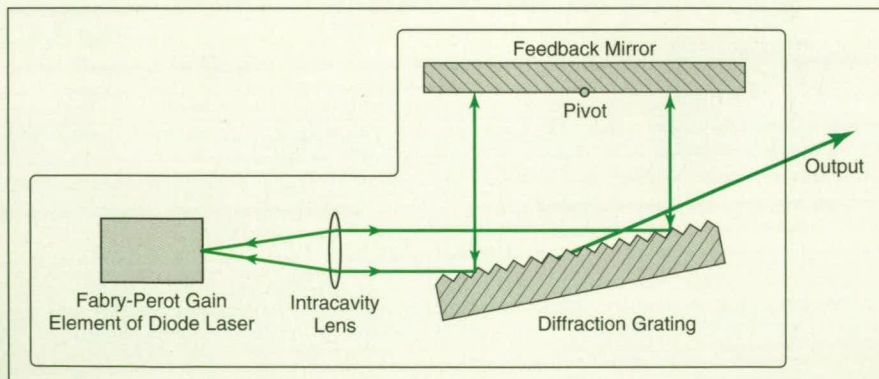
The present prototype ECDL (see figure) is simple and inexpensive, relative to prior commercial ECDLs. Its design combines the stability of an external-

cavity laser with the wavelength agility of a diode laser. The design allows for wavelength modulation of the ECDL by modulation of the diode gain element injection current. The external cavity is of a type known in the art as a Littman-Metcalf resonator, in which the zeroth-order output from a diffraction grating is used as the laser output and the first-order-diffracted light is retroreflected by a cavity feedback mirror, which establishes one end of the resonator. The other end of the resonator is the output surface of a Fabry-Perot resonator that constitutes the diode-laser gain element. Wavelength selectivity is achieved by choice of the angle of the diffracted return beam, as determined by position of the feedback mirror.

The diode laser in the prototype wavelength-agile ECDL is of a room-temperature ultraviolet type that has recently become commercially available. However, the design principle is just as well adaptable to other diode lasers. The feasibility of the developmental instruments has been demonstrated by using the prototype wavelength-agile ECDL as the source of light in a prototype WMS spectrometer for measuring concentrations of CH radicals in laboratory flames.

*This work was done by Jeffrey S. Pilgrim and Daniel B. Oh of Southwest Sciences, Inc., for Glenn Research Center.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17090.*



A Littman-Metcalf Resonator is used as an external cavity resonator in the wavelength-agile ECDL.

### Picosecond Performance!

#### Capabilities:

- Ultrashort Pulses ( $\leq 800$  psec.)
- Standard TO-3 Package
- Wavelengths: 1064 & 532 nm
- 35 mW @ 1064 nm
- 20 mW @ 532 nm
- 7 kW Peak Power @ 1064 nm
- > 5,000 Hr. Lifetime @ 25 °C

#### Applications:

- Industrial (Marking/Scribing)
- Aerospace (Testing)
- Medical (Analysis)
- Military (Ranging)
- Environmental (Spectroscopy)

#### Contact us for more information:

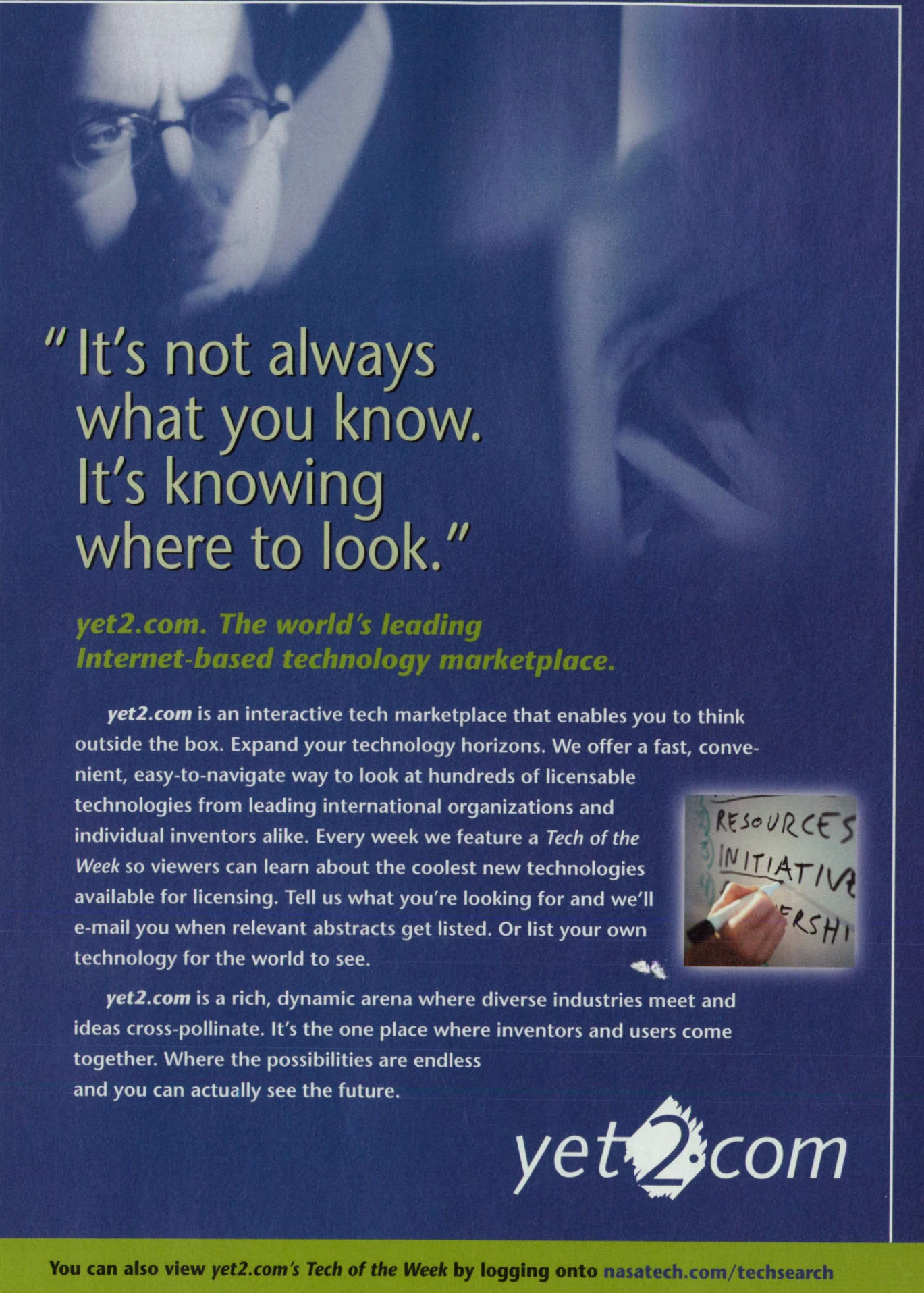
Phone: 704.588.2340  
Fax: 704.588.2516

**Litton**

**Airtron SYNOPSIS**

1201 Continental Blvd  
Charlotte, NC 28273



A large, dark, blue-tinted background image of a man with glasses looking at a screen, with his hand raised as if pointing at something.

"It's not always  
what you know.  
It's knowing  
where to look."

**yet2.com. The world's leading  
Internet-based technology marketplace.**

yet2.com is an interactive tech marketplace that enables you to think outside the box. Expand your technology horizons. We offer a fast, convenient, easy-to-navigate way to look at hundreds of licensable technologies from leading international organizations and individual inventors alike. Every week we feature a *Tech of the Week* so viewers can learn about the coolest new technologies available for licensing. Tell us what you're looking for and we'll e-mail you when relevant abstracts get listed. Or list your own technology for the world to see.



yet2.com is a rich, dynamic arena where diverse industries meet and ideas cross-pollinate. It's the one place where inventors and users come together. Where the possibilities are endless and you can actually see the future.

yet2.com

You can also view yet2.com's *Tech of the Week* by logging onto [nasatech.com/techsearch](http://nasatech.com/techsearch)



# Thermal Imaging for Diagnosing Fuel Cells

A single image reveals a variety of phenomena important to fuel-cell operation.

NASA's Jet Propulsion Laboratory, Pasadena, California

Thermal (that is, infrared) imaging has been demonstrated to be an effective technique for the diagnosis of operating fuel cells and fuel-cell stacks. Thermal imaging can be used to identify a variety of phenomena, described below, that are associated with nonuniform generation of heat. Hence, thermal imaging is expected to be widely used in

fuel-cell research, development, and manufacturing.

The performances of fuel-cell stacks (especially micro-fuel-cell stacks) are commonly adversely affected by nonuniform distributions of fuel, high resistances of electrical interconnections, cell-to-cell variations, and other phenomena associated with nonuniform

generation of heat. The analysis of such phenomena by means of individual cell measurements (e.g., point-probe electric-potential measurements) can be quite tedious, even for a short stack; in the case of flat-pack micro-fuel cells, such measurements are almost impossible. Under these circumstances, one is often left guessing as to the causes of reduced performance.

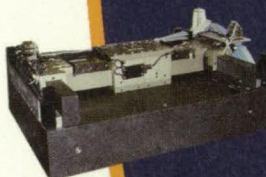
The generation of heat always accompanies the operation of a fuel cell. The generation of heat is due to inefficiency of the basic fuel-cell electrochemical reaction, crossover (residual diffusion through the fuel-cell solid-electrolyte membrane) of fuel (usually, the fuel is methanol), and electrical heating of interconnection resistances. Temperature differences occur if any of these heat-generating processes occur differently in different parts of a fuel-cell stack. For example:

- Nonuniform distribution of fuel across the surfaces of electrodes leads to nonuniform distribution of electric current and hence temperature differences;
- High-resistance interconnections in a

## PRECISION POSITIONING SYSTEMS

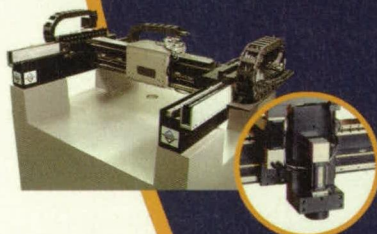
### Planar Air Bearing Series

- Full preload on all axes
- Dual linear-motor-driven Y axis
- Travel to 1 meter x 1 meter



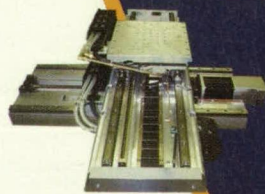
### Linear Motor Gantry Systems

- High velocity to 3 m/s and high acceleration to 5 g
- Highest throughput gantry in the world
- Applications include pick and place, assembly, vision inspection, and more



### Ultra-High Vacuum Systems

- Heavy-duty vacuum preparation to  $10^{-6}$  torr
- Liquid-cooled linear motor drive for smooth scanning motion and high power
- Linear encoder feedback



### Ultra-High Resolution, Integrated Nano-Positioners

- Up to six axes of precise motion
- Noncontact direct-drive for all axes
- 10 nm resolution X-Z axis, 2 nm resolution Y axis, and 0.05 arc-sec resolution for roll, pitch, and yaw



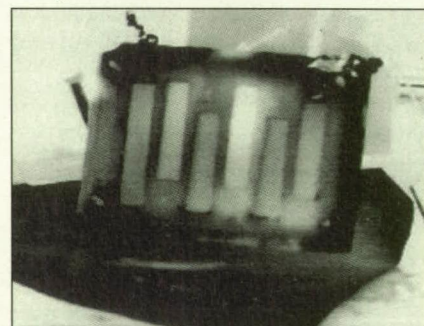
[www.aerotech.com](http://www.aerotech.com)



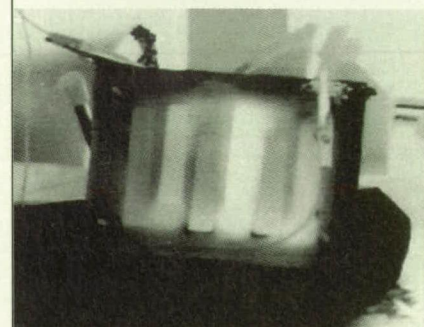
Dedicated to the  
Science of Motion

AI0701A

AEROTECH, Inc., 101 Zeta Drive, Pittsburgh, PA 15238  
Ph: 412.963.7470 • Fax: 412.963.7459  
E-mail: [sales@aerotech.com](mailto:sales@aerotech.com)



OPEN CIRCUIT

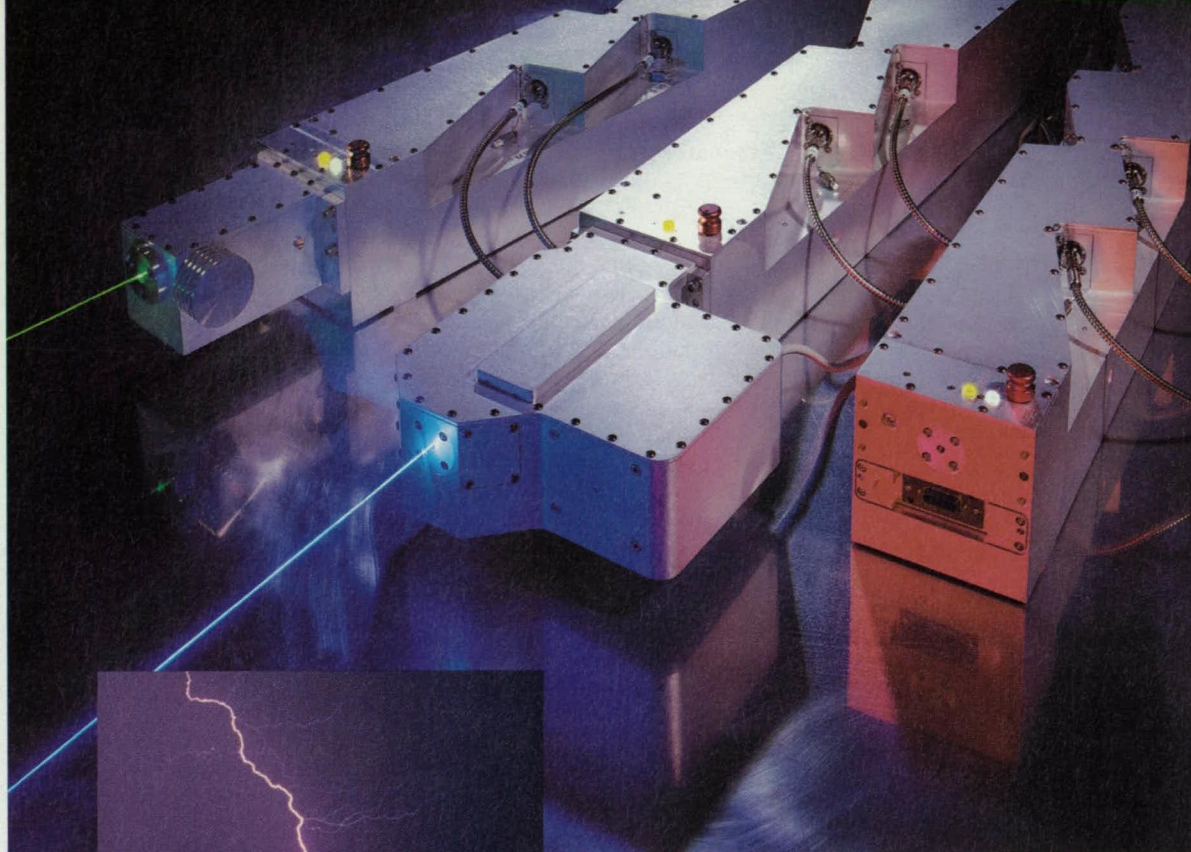


ELECTRICAL LOAD CONNECTED

These Infrared Images of the cathode side of a six-fuel-cell flat pack were recorded under two operating conditions. The nonuniformities of temperature depicted in these images can be analyzed to extract information about processes in the fuel cells and their electrical interconnections.



Inazuma (Japanese for lightning) high power Q-switched lasers in green, UV, and IR.



## Inazuma™: The Power Of Lightning

Inazuma Laser System  
Long lifetime, high uptime  
Field interchangeable harmonic modules  
Sealed resonator  
Patented **FCbar™** technology

>8W @ 355 nm  
>20W @ 532 nm  
>35W @ 1064 nm



Introducing Inazuma, our new ultra-high power laser that generates over 8W of UV. For exceptional performance, Inazuma utilizes a periodic resonator, further scaling up the power of our field proven **FCbar™** technology. Versatile by design, our propri-

etary harmonic modules deliver years, not hours,

of uptime for microvia hole drilling and other high speed precision processing applications. These modular components can be easily exchanged in the field without returning the laser to the factory—a unique Spectra-Physics feature that keeps the system where you want it, hard at work. With more than 700 units in the field, we have the largest installed base of solid state UV laser systems. Call us for ultra-high power you can rely on.

 **Spectra-Physics**

The Solid State Laser Company™

Call: 1-800-SPL-LASER (775-5273)

Web: [www.spectra-physics.com](http://www.spectra-physics.com)

E-mail: [sales@splasers.com](mailto:sales@splasers.com)

© 2001 Spectra-Physics

For Free Info Circle No. 538 or Enter 538 at [www.pnasatosh.com/cr](http://www.pnasatosh.com/cr)



## Miniature Spectros reliable & low cost Instrumentation

### UV-VIS-NIR

#### Fiber Optic SPECTROMETERS

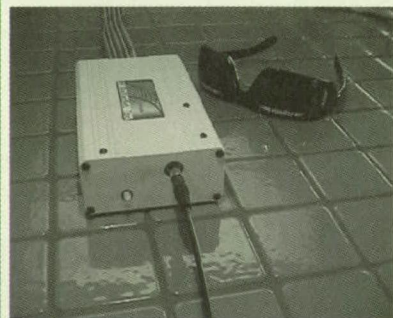
MEASURE Absorbance, Transmittance, Reflectance, Irradiance, Fluorescence, Chemical concentrations, Colors of light, LEDs, Laser  $\lambda$ , Plasma, and Thin Films.

Turnkey Systems >> SpectroRadiometers  
SpectroColorimeters SpectroFluorimeters  
Optical Spectrum Analyzers 190-1620nm  
UV/VIS 190-850nm VIS/NIR350-1150nm

CCD/PDA detectors with built-in A2D  
Superb spectral imaging & resolution  
Acquire 2000 wavelengths in just 4ms.

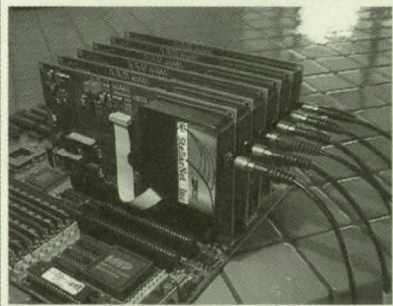
**SpectraWiz® Software**  
Free Win9x/NT/00 Program & Drivers

### EPP2000 Portable



connect to PC printer port  
daisy-chain for multi-beam!

### ISA2000 Plug-in



[www.stellarnet-inc.com](http://www.stellarnet-inc.com)



13801 M Cormick Drive  
Tampa, FL 33626 USA  
813-855-8687 / 813-855-2279 fax

For Free Info Circle No. 498 or  
Visit [www.nasatech.com/498](http://www.nasatech.com/498)

stack distinguish themselves by producing more heat than the others do; and

- Variations among cells within a stack, arising from variables in fabrication, can cause one or more cells to be more efficient than the others are, leading to thermal gradients.

These examples illustrate how mapping the surface temperature of a fuel-cell stack during operation can yield useful information about the processes occurring in the stack.

Infrared cameras equipped with quantum-well infrared photodetectors (QWIPs) can detect temperature differences as small as 0.005 K. Such a camera has been found to be particularly useful for monitoring processes in fuel cells. For example, the figure shows the temperature variations on

the cathode side of a six-fuel-cell flat pack, both in the open-circuit condition and with an electrical load connected. The cell marked 4 exhibits a temperature greater than do the others, even in the open-circuit condition: this is attributed to a high methanol-crossover rate in the particular cell. With the load connected, the interconnections also exhibit differences in temperature, and some of them can be identified to be substantially more resistive than others are.

*This work was done by Sekharipuram Narayanan and Thomas Valdez of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category.*  
NPO-21177

## Fiber-Optic Illumination for Microscope

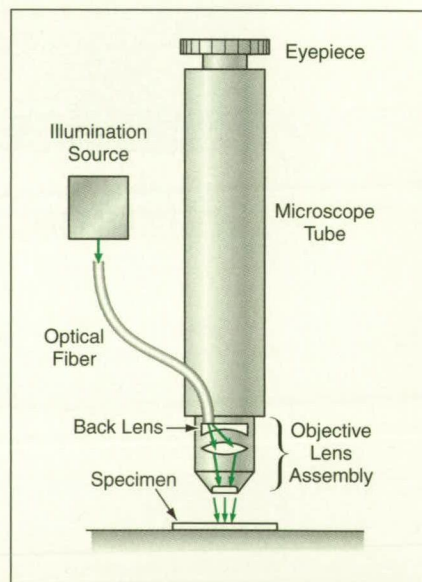
Light is injected at the edge of the objective back lens.

NASA's Jet Propulsion Laboratory, Pasadena, California

In a simple but very effective method for providing intense illumination of an opaque specimen under a microscope, light is supplied via an optical fiber. This system eliminates the need for traditional Köhler-type vertical illumination system components, such as beam splitters and lenses, and is easily adaptable to vacuum environments. The output end of the fiber is placed at the edge of the microscope objective back lens (see figure), near the pupil. The light from the fiber passes down through the objective lens, which concentrates the light onto the specimen.

Tests indicate that alignment of the fiber is not critical since the fiber is not imaged at the specimen. The microscope tube may be a slightly modified commercial off-the-shelf unit, or the fiber may be integrated into the microscope objective lens with a detachable fiber connector so that completely unmodified microscope bodies can be adapted to vertical illumination at low cost. This fiber-optic illumination scheme is expected to be especially useful in microscopy of semiconductor or metallurgical specimens and other opaque objects, as well as in biomedical microscopy.

*This work was done by Hiroshi Kadowa of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category.*



**Light Is Supplied** from an external lamp via an optical fiber, using the microscope objective lens to focus the light onto the specimen. This simple illumination scheme is relatively inexpensive and, in many cases, more effective than are conventional vertical-illumination schemes that involve complex and bulky optical systems with beam splitters, which waste light.

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Management Office-JPL; (818) 354-2240. Refer to NPO-19484.*



# Enhanced Optical Microresonators for Detecting Molecules

**Sensitivity and selectivity would be enhanced by use of fluorophores.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Sensors based on microscopic optical resonators and arrays of such resonators have been proposed for detecting trace amounts of specific molecules in small gaseous, liquid, and solid samples. In addition to compactness, these sensors would offer ultrahigh sensitivity — in some cases, enough sensitivity to detect single molecules. These sensors could be especially useful in biochemical and biomedical applications.

The proposed sensors would be enhanced versions of the sensors reported in "Microsphere and Microcavity Optical-Absorption Sensors" (NPO-21061), *NASA Tech Briefs*, Vol. 25, No. 4 (April 2001), page 12a. To recapitulate:

The transducer in a sensor of this type is a fiber-optic-coupled optical resonator in the form of a transparent microspheroid or a microcavity optically equivalent to a microspheroid. Resonance is achieved through grazing-incidence total internal reflection in one or more "whispering-gallery" modes, in which light propagates in equatorial planes near the surface, with integer numbers of wavelengths along closed circumferential trajectories. In the absence of external influences, and assuming that the microspheroid or microcavity is made of a low-loss material, the high degree of confinement of light in whispering-gallery modes results in a high resonance quality factor (high  $Q$ ).

Suppose that the resonator is illuminated by laser light at its resonance wavelength and is immersed in a sample liquid or gas that has an index of refraction less than that of the resonator material and contains a highly diluted chemical species of interest that absorb light at the resonance wavelength. In that case, the  $Q$  of the resonator is diminished through absorption by molecules of that species in the evanescent field of the whispering-gallery modes. Because of the smallness of microresonators (typical diameters from tens to hundreds of optical wavelengths), the smallness of the effective volumes of the evanescent fields (as small as  $10^{-10}$  cm<sup>3</sup>), and the low level of optical losses intrinsic to resonators themselves, it is possible to detect very small amounts of optically absorbing chemical species through decreases in  $Q$ ; calculations have shown that in some cases, it should be possible to detect amounts as small as single atoms or molecules. This completes the

recapitulation of information from the cited prior article.

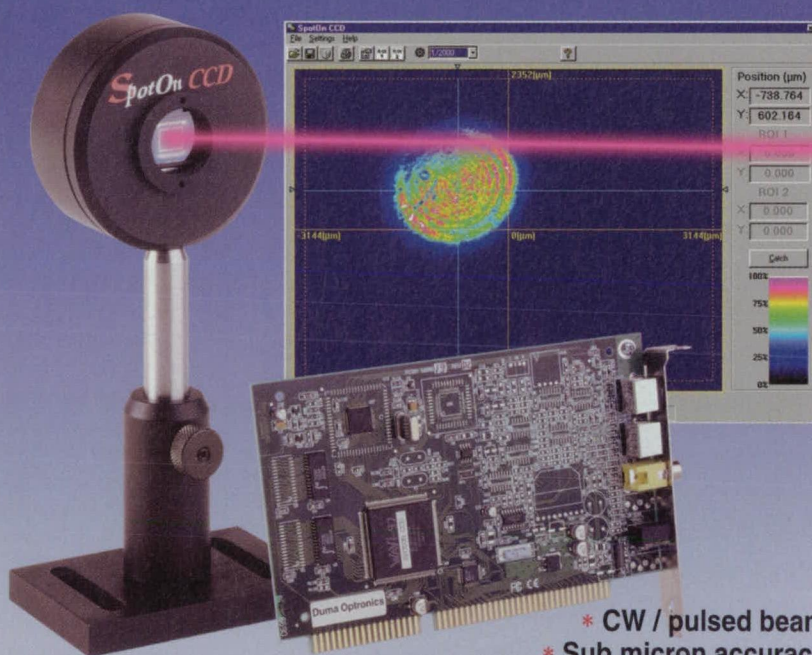
The basic principle of operation as described thus far does not, by itself, afford the sensitivity and selectivity needed to detect a specific chemical species in a quantity as small as a single molecule. What is needed to realize the desired capability is a means of obtaining optical absorption and/or emission at one or more specific wavelengths characteristic of transitions between energy levels of the molecule of interest. Toward this end, the present proposal calls for one or more of the following enhancements:

- The molecules of interest could be marked by use of fluorescent dye molecules that site-specifically bind to them. The microresonator for use in this case would be one that was designed to resonate at a wavelength at which the dye fluoresces. Provided that the microresonator had a  $Q$  of at least  $10^9$  in the absence of the fluorescent dye and the species of interest, it should be possible to detect the absorption of resonator light by a single

tagged molecule. The emission of light from the fluorophore could serve, in addition to the absorption-induced decrease in  $Q$ , as an amplified indication of the molecular specifics of interest.

- A microresonator would be coated with fluorophores that bind to the molecules of interest. The thickness of the fluorophore coat (typically less than 100 nm) would be small enough that the coat would not significantly alter the  $Q$  of the resonator in the absence of the molecules of interest and would be less than the characteristic decay length of the evanescent field. Once a molecule of interest became bound to the coat, the  $Q$  of the resonator would change, indicating the presence of the molecule.
- A fluorophore coat like the one described in the preceding paragraph could be applied at an interface between an optical fiber and a microresonator, instead of over the surface of the resonator. In this case, the fluorophore coat by itself would exert little effect on the coupling between the op-

## EXPANDING YOUR POSITIONING CAPABILITIES



**\* CW / pulsed beam**  
**\* Sub micron accuracy**



**DUMA OPTRONICS LTD.**

Tel: 972-4-8200577 Fax: 972-4-8204190

P.O.B. 3370 Neshet 20306 Israel

E-Mail: [sales@duma.co.il](mailto:sales@duma.co.il)

Website: [www.duma.co.il](http://www.duma.co.il)



## STATE-OF-THE-ART POLARIZATION MODULATION

**PEM-90™ Photoelastic Modulators**  
for high-speed chopping (20-200kHz)  
and high-sensitivity measurements in:

- Low-level Birefringence
- Stokes Polarimetry
- Ellipsometry
- Magnetic Kerr Effect
- Spectroscopy

**PEM-90 modulators provide:**

- Large spectral range (130 nm-18 $\mu$ m)
- Excellent modulation purity
- High sensitivity (10°)
- Large aperture (13-29mm)
- Wide acceptance angle ( $\pm 20^\circ$ )
- RS232 and GPIB capability



Hinds Instruments, Inc.  
Phone 503/690-2000  
Fax 503/690-3000  
info@hindspem.com  
www.hindspem.com

For a free technical guide  
call 1 800 688-4463

For Free Info Circle No. 460 or  
Enter No. 460 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

## Hard to Find Positioning Equipment!

**H**undreds of models  
to choose from

Linear Slides  
Rotary Tables  
X-Y Tables

Widths: 1.5 in. to 9 in.  
Lengths: 2 in. to 90 in.

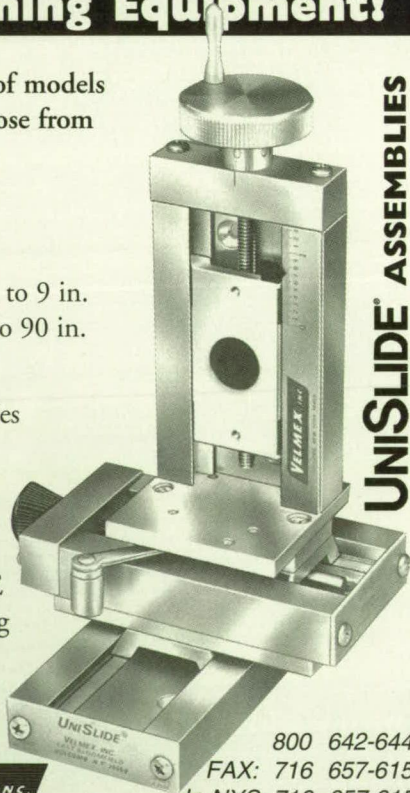
Single or  
OEM Quantities

Compact  
Durable  
Economical

Get your **FREE**  
48 page Catalog  
& price list.

**Call: 800  
642-6446**

**VELMEX INC.**  
[www.velmex.com/b](http://www.velmex.com/b)



**UNISLIDE™ ASSEMBLIES**

800 642-6446  
FAX: 716 657-6153  
In NYS: 716 657-6151  
Bloomfield, N.Y. 14469

For Free Info Circle No. 466 or  
Enter No. 466 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

tical fiber and the resonator, but in the presence of a molecule of interest, the optical-transmission characteristic of the sensor would change measurably.

Going a step further, a sensor according to the proposal could be constructed as an array of multiple fiber-optic-coupled microresonators microfabricated on a silicon or other substrate. The microfabrication of the sensor array on the substrate could include etching of channels to support flows of sampled fluids. Each microresonator could be coated with a fluorophore that binds to a different molecule of interest, so that the sensor could detect many molecular species of interest simultaneously.

*This work was done by Lutfollah Maleki and Vladimir Ilchenko of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to*

*Intellectual Property group*

*JPL*

*Mail Stop 202-233*

*4800 Oak Grove Drive*

*Pasadena, CA 91109*

*(818) 354-2240*

*Refer to NPO-21239, volume and number of this NASA Tech Briefs issue, and the page number.*

## System for Measuring Three Tilts and Distance of an Object Relative to conventional optical alignment instruments, this system costs less.

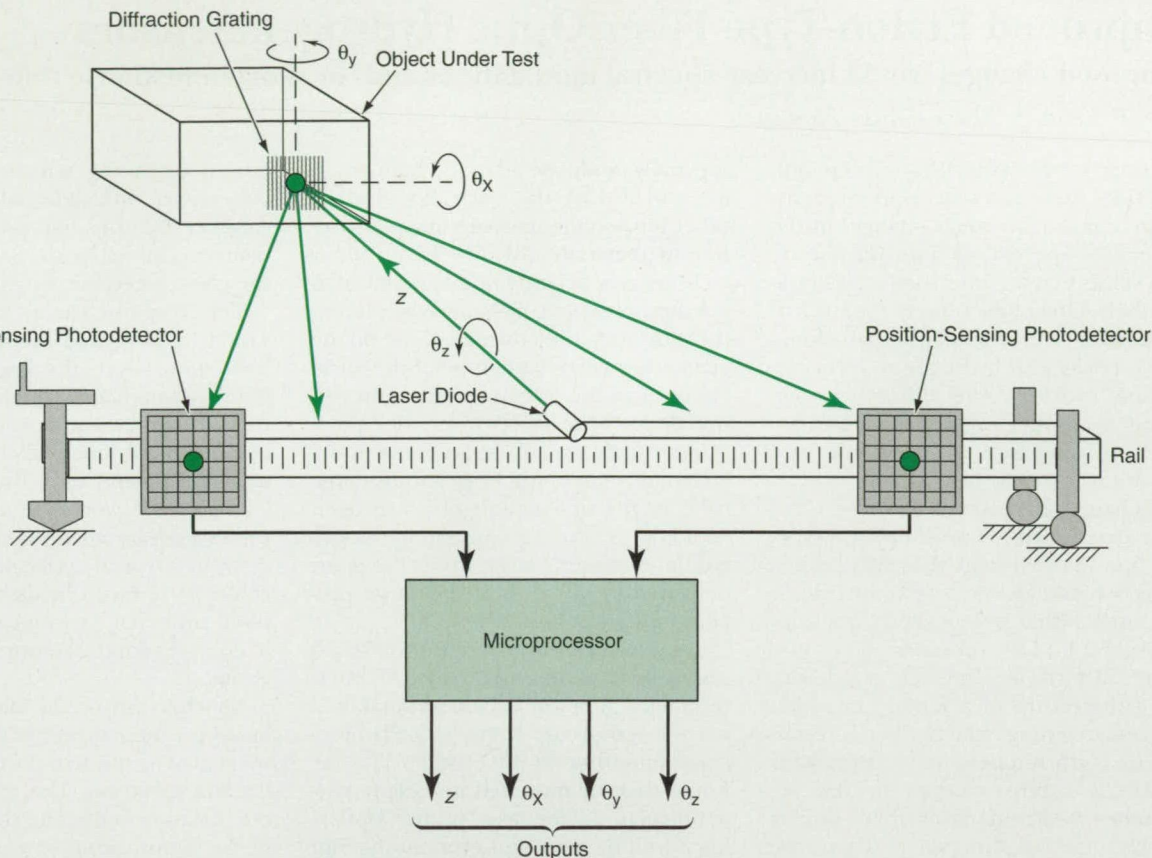
*NASA's Jet Propulsion Laboratory, Pasadena, California*

An optoelectronic system discussed herein measures the state of alignment (SOA) of an object under test in four of its six degrees of freedom (DOFs). This system was originally intended for use in determining the SOA of an optical bench in a vacuum chamber. The basic design and mode of operation of this system are also applicable to similar measurement problems that arise in a variety of endeavors, including general alignment of optics, alignment of structures, studies of deformations of structures, geodetic surveying, photogrammetry, and construction. Heretofore, in order to obtain the alignment information provided by this system, it would have been necessary to use at least two expensive theodolites or else multiple expensive low-distortion camera heads aimed along different lines of sight. The present system contains simpler, less-expensive optics, and its basic design is amenable to tradeoffs among range, sensitivity, and configuration.

The prototype of the system (see figure) includes (1) a reflective diffraction grating mounted on the object under test; (2) a collimated laser diode fixed in a known position and orientation on, and relative to, a dimensionally stable rail; and (3) at least two position-sensing photodetectors mounted at known positions and orientations on the rail. In an alternative version, the laser diode could be affixed to the object under test.

The laser diode is aimed toward the expected location of the reflective diffraction grating on the object under test, thereby generating a fanlike array of diffracted, collimated laser beams. The position-sensing photodetectors are positioned and oriented so that at least one of the diffracted beams would be in-





From the Measured Positions of the Laser Spots on the position-sensing photodiodes, the parameters  $z$ ,  $\theta_x$ ,  $\theta_y$ , and  $\theta_z$  are calculated.

tercepted by each such detector if the object under test were in approximately the expected alignment. The outputs of the detectors are digitized, processed by image-data-processing software, and further processed by software that implements the geometric relationships among (1) the locations of the centroids of the laser-beam spots on the detectors, (2) the laser wavelength, (3) the spatial period of the grating, (4) the distance between detectors, (5) the diffraction order, and (6) the position and orientation of the diffraction grating (and thus of the object under test). The final data product is a set of parameters that specify the position and orientation of the object in four degrees of freedom: range (distance along the laser beam between the laser diode and the center of the grating), the angle of rotation ( $\theta_z$ ) of the grating about the laser-beam axis, and the angles of rotation ( $\theta_x$  and  $\theta_y$ ) of the grating about two coordinate axes perpendicular to the beam axis.

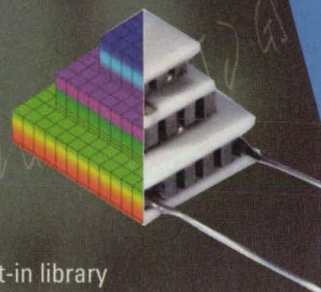
This work was done by Eric B. Hochberg of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free online at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category. NPO-21086

## The ONLY Equation You Need

**HARVARD THERMAL + MELCOR =**  
*A Total Solution*

**Include TE Cooler Functionality in Your TASThermal Model**

- Simulate cooling and heating mode
- Control voltage or current
- Select a Melcor part number from the built-in library



**HARVARD THERMAL, INC.**  
 Tel: 978-772-3800  
[www.HarvardThermal.com](http://www.HarvardThermal.com)

**MELCOR CORP.**  
 Tel: 609-393-4178  
[www.melcor.com](http://www.melcor.com)



# Improved Etalon-Type Fiber-Optic Hydrogen Sensors

Proposed changes would increase spectral modulations and/or shorten response times.

John F. Kennedy Space Center, Florida

Three modifications have been proposed for hydrogen sensors in which hydrogen in the air causes changes in the reflection spectra of interferometric film stacks that are interrogated via optical fibers. One of the films in the stack in each such sensor contains palladium, which reacts with hydrogen to form palladium hydride. The differences between the optical absorbances and indices of refraction of palladium and palladium hydride give rise to observable changes in spectra.

In an unmodified sensor of this type, the film that contains the palladium is reflective and is the outermost film in the stack, which is deposited on a thin, transparent glass substrate. The substrate, in turn, is adhesively bonded to the polished tip of a ferrule in which the interrogating optical fiber is terminated. Unfortunately, it is difficult to obtain a robust change in the reflectance spectrum of this or any similar interferometric film stack when the outermost film is the one that changes. In this case, the differences between the indices of refraction and optical absorbances of palladium and palladium hydride in the outermost layer are not large enough to elicit the desired robust change.

The situation would be different if the film containing the palladium were the innermost layer in the stack (the layer closest to the interrogating optical fiber), because in such a case, the film would

spectrally modulate all of the light entering and leaving the stack. Because the other films in the stack are made of non-porous materials with low permeability by hydrogen, it would not be practical to attempt to exploit this effect by placing the film containing the palladium on the glass substrate at the bottom of the stack. However, if the stack from the unmodified design were simply inverted and positioned with a small airgap between the palladium-containing layer and the optical fiber, the air containing the hydrogen could diffuse through the gap to the palladium-containing layer: this is the point of departure for one of the three proposed modifications.

Figure 1 illustrates a reflection-based sensor head as thus modified. The interferometric film would be deposited on a narrow sensor bar with the palladium-containing film on the outside. The bar would then be mounted in a plane perpendicular to the axis of the optical fiber, with the palladium-containing film facing the polished end of the fiber across an airgap about 0.1 mm wide. The gap would be maintained by use of a glass or ceramic ring bonded adhesively to the tip of a capillary tube, which would serve as a pedestal and as a ferrule to hold the optical fiber. A thin-film electrical heater could be deposited on the sensor bar along with the interferometric films to obtain intimate thermal contact and thus highly energy-efficient heating of the films to maintain the re-

quired operating temperature. Electrical contact with external circuitry that supplies the heating power could be made via metal pads evaporated onto the glass or ceramic ring.

The response delay of the sensor would be governed by the diffusion of hydrogen. Given the known diffusivity of hydrogen in air, it has been estimated that at standard atmospheric pressure and a temperature of 20 °C, the characteristic diffusion time for a sensor bar 0.2 mm wide would be about 0.11 ms; this would be an acceptable response delay in a typical application. The delay could be reduced by use of an air-sampling unit that provides sufficient flow in contact with the sensor bar and its environs.

Another proposed modification is based on the concept of measuring the transmission spectrum instead of the reflection spectrum. The impetus for this modification is the fact that the change in the transmission of a palladium-containing film upon exposure to hydrogen exceeds the change in its reflection; consequently, at a given hydrogen concentration, the output of a transmission-based sensor should exceed that of the reflection-based sensor described above.

Figure 2 shows two alternative configurations for the proposed transmission-based sensor. In the first configuration, light from a small source would be collimated by a lens. The light would pass through the etalon, then through an-

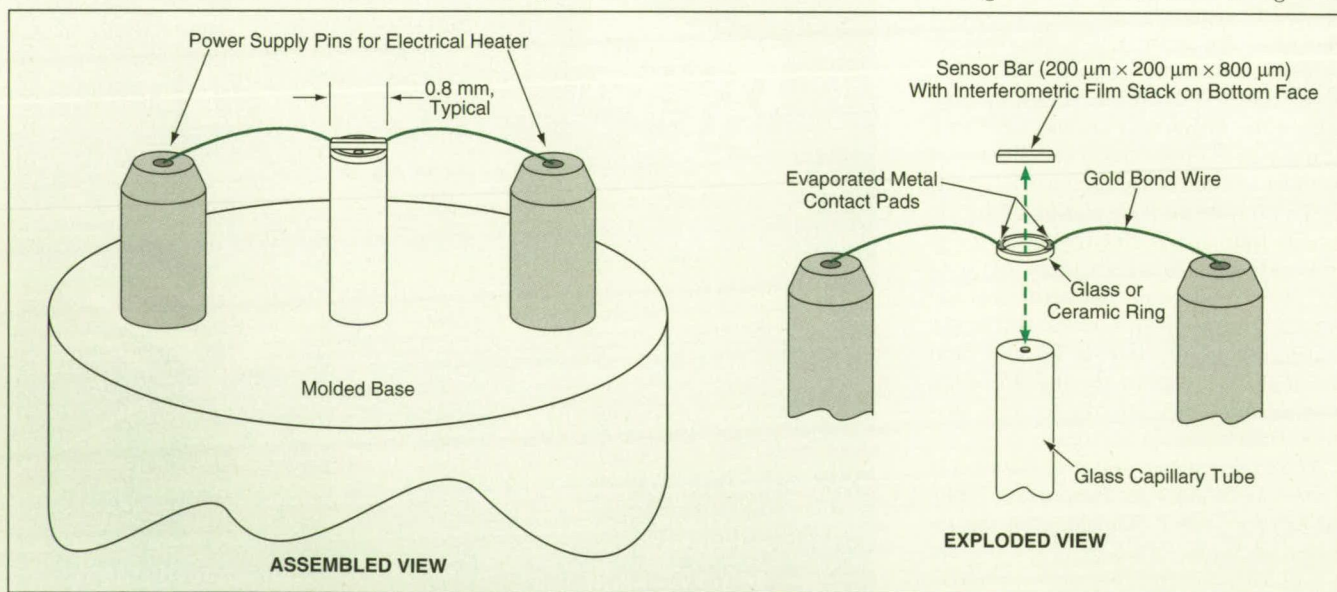


Figure 1. The Interferometric Film Stack on the bottom of the sensor bar would exhibit a reflectance spectrum that would depend on the hydrogen content of the air in contact with a palladium-containing layer facing the optical fiber. The stack would be interrogated via the optical fiber.



other lens that would focus the light onto a photodetector. Hydrogen would diffuse to the etalon through a small air-gap between the etalon and the focusing GRIN lens.

The source of light could be two light-emitting diodes (LEDs) of different colors mounted in proximity on the same header. One LED would be chosen to have a wavelength (about 450 nm) in the vicinity of maximum change in transmission upon exposure to hydrogen. The other LED would be chosen to have a wavelength (typically in the infrared) for which there is little change in optical properties on exposure to hydrogen; the signal from this LED would serve as an amplitude reference.

Alternatively, the source of light could comprise multiple LEDs that would be turned on and off in sequence to obtain the transmission responses at the various LED wavelengths. Yet another alternative would be to illuminate the etalon with white light, in which case it would be necessary to analyze the transmitted light by use of a spectrometer. A suitable spectrometer could be constructed from a diffraction grating and a linear array of photodiodes. This alternative would provide more information than would the two-LED design described above, albeit at increased complexity and cost.

Although lenses shown in the figure are of the gradient-index-of-refraction (GRIN) type, other types could be used. The advantage of GRIN lenses in this application is that their ends can be made flat; this makes it possible to fabricate the etalon directly on the end of the collimating lens, reducing the size and complexity of the sensor.

The second configuration would involve the same principle of operation, but light would be coupled into and out of the sensor by different means. In this configuration, light would be delivered to the etalon from a remote source via a first optical fiber, and light transmitted through the etalon would be delivered to the photodetector(s) or spectrometer via a second optical fiber. In this case, the etalon could be fabricated on the polished output end of the first optical fiber, and the airgap would lie between the etalon and the input end of the second optical fiber. (Alternatively, the etalon could be fabricated on the end of the second optical fiber.) The core of the second fiber would be made wider than the core of the first fiber so that the second fiber could capture all of the transmitted light, without need for a collimating and a focusing lens.

The use of optical fibers would make it possible to mount the sensor away

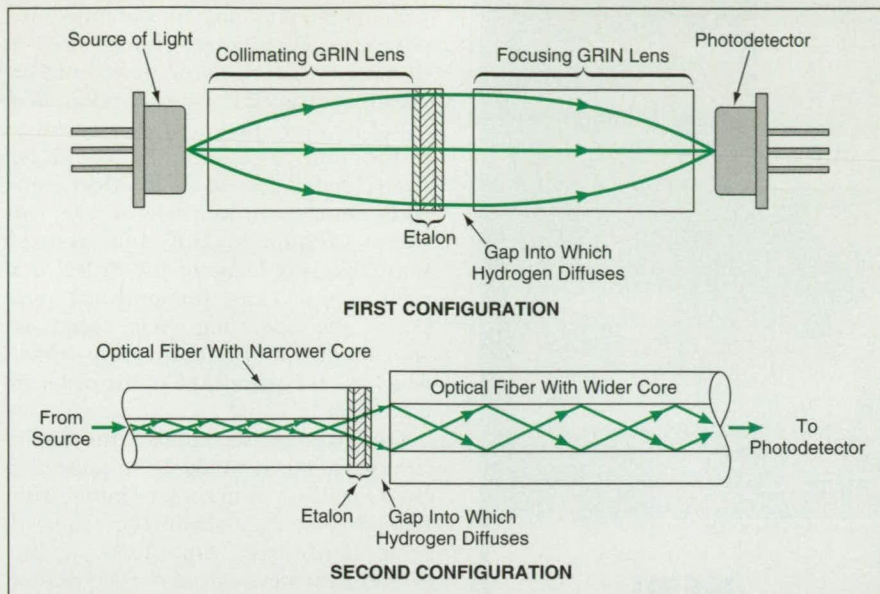


Figure 2. Light Would Be Transmitted through an etalon, the transmission spectrum of which would be altered by hydrogen in the air.

from the associated electronic circuitry. This could be advantageous in situations in which the circuitry would be vulnerable to electromagnetic interference or to damage if it were placed at the sensor location.

The third modification would be the introduction of pulsed optical heating to decrease response times. This modi-

fication would exploit the observations that (1) the response time in desorption of hydrogen is typically about 12 times that in absorption, (2) the response time decreases with temperature, and (3) optical modulation goes to zero as the temperature is increased to 80 °C, suggesting that all of the hydrogen becomes desorbed from the

# Stop Searching

"VACUUM UV" + "X-RAY IMAGING"

Search

[www.roperscientific.com/sxmte](http://www.roperscientific.com/sxmte)





**Low Stress  
Low Movement**

**NEW!**

## **LIGHT CURING ADHESIVES**

**For Low Stress  
and Low Movement**

- ◆ **Shrinkage to 0.1%**
- ◆ **Low to High Modulus**
- ◆ **Low to High  $T_g$   
to 100°C+**
- ◆ **Refractive Index  
from 1.42 to 1.59**

**Download the  
white paper or  
order adhesives  
on-line at:**

[http://www.dymax.com/  
products/optical/optical.asp](http://www.dymax.com/products/optical/optical.asp)



**DYMAX®**  
Adhesives and Light Curing Systems  
51 Greenwoods Road, Torrington, CT 06790

**Phone: (860) 482-1010**

For Free Info Circle No. 447 or  
Enter No. 447 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

palladium-containing film at this temperature. These observations suggest that the overall response time could be greatly shortened if the desorption time could be shortened, and, in particular, if the film containing Pd could be heated quickly to 80 °C to effect complete desorption. In a typical case, the thermal-response (and thus desorption) time would be of the order of a millisecond. Thus, for practical purposes, the operating cycle could be shortened to the absorption time, which would typically be of the order of a minute.

One way to accomplish the rapid heating to 80 °C would be to pulse the interrogating source of light with enough power to obtain the required temperature rise. Optionally, if the pulsed light were infrared, then one of the films in the etalon (not necessarily

the one containing Pd) could be made of InSb to enhance absorption of infrared. In the case of a transmission-based etalon sensor, the fraction of light transmitted would change during each illuminating pulse; specifically, the film containing Pd would become less transparent as the hydrogen was desorbed. Thus, the hydrogen content of the air could be inferred from the decrease, during each pulse, in the fraction of light transmitted. As an important side benefit of this approach, there would be no need to provide additional means to generate a reference or baseline signal because the optical signal would be returned to its baseline level as the hydrogen was expelled with each pulse.

*This work was done by Elric W. Saaski and Charles Young of Research International, Inc., for Kennedy Space Center. KSC-11981*

## **Algorithm for Optimizing Designs of Diffractive Optics**

**Diffractive optical elements with continuous phase profiles can be designed rapidly.**

*Marshall Space Flight Center, Alabama*

An algorithm for optimizing the designs of diffractive optics is based on constrained dynamics and the reciprocity of electromagnetic propagation. This algorithm can contribute to realization of the potential of diffractive optics, which offer capabilities greater than those of refractive optics. Because the diffractive-optics design-optimization problem is equivalent to determining the diffractive limit of phase-only propagation compensation by adaptive optics, the algorithm could be used to create control algorithms for adaptive optics. In addition, the mathematical techniques and physical principles used in developing the algorithm could be used in solving the problem of phase retrieval for characterizing wavefronts.

The design and optimization of diffractive optics are generally more complex and computationally intensive than are the design and optimization of refractive optics. Prior to the development of the present algorithm, most of algorithms used for the same purpose were based on propagation only in the forward direction; that is, from the diffractive optical element(s) to the diffraction plane. In each such prior algorithm, an initial guess (often a random configuration) of the design of the diffractive op-

tical element(s) is made, and stochastic integration techniques are used to improve the initial guess by generating more random configurations and then deciding which ones are better and headed in the direction of the desired optimized design. Such algorithms are computationally inefficient (and hence time-consuming) because they must generate many tentative design configurations, most of which must be discarded because they are far removed from design specifications.

The computational burden associated with generating many random configurations makes it impractical to produce designs with more than a limited number of degrees of freedom per phase-template pixel; that is, phase templates generated by such algorithms can contain only a few quantized levels or steps in phase. However, it is possible to manufacture diffractive optical elements with continuous phase profiles.

Hence, what is needed to realize the potential of diffractive optics is a computationally efficient algorithm that generates phase templates with continuous phase profiles. The present algorithm satisfies this need. Because random configurations are not used and physical



quantities are treated as continuous in the first place, there are no restrictions on the number of degrees of freedom per phase-template pixel.

Mathematically, reciprocity of electromagnetic propagation is a consequence of the symmetry of Maxwell's equations. The present algorithm takes advantage of the reciprocity of electromagnetic propagation to propagate design information both from the diffractive optical elements forward to the diffraction plane and from the diffraction plane backward to the diffractive optical element(s). In so doing, the algorithm utilizes maximally the information available on both the diffractive-element and diffraction planes. Moreover, because the algorithm is ultimately based on Maxwell's equations, it can, in principle, be applied to a wide variety of diffractive optical elements, including those for which vector diffraction analysis is necessary.

The constrained-dynamics aspect of the algorithm makes it possible to solve the design-optimization problem through successive approximation. Each iteration brings the design solution closer to the optimized design solution, and no randomness is involved.

*This work was done by S. Enguehard and B. Hatfield of Applied Mathematical Physics Research, Inc., for Marshall Space Flight Center. For further information, contact the company at (781) 862-6357, or access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to*

*Applied Mathematical Physics Research, Inc.  
420 Bedford Street  
Suite 230*

*Lexington, MA 02420*

*Refer to MFS-31427, volume and number of this NASA Tech Briefs issue, and the page number.*

## Computer Program for Designing Diffractive Optics

**This program fills a gap left by available refractive-optics-design software.**

*Marshall Space Flight Center, Alabama*

AMPERES is a prototype computer program that implements the algorithm, described in the preceding article, for optimizing designs of diffractive optics. Several other programs for designing refractive optics are commercially available, but they offer very limited capabilities with respect to diffractive optics. AMPERES was developed to fill this gap and to serve as an easy-to-use means for designing diffractive optics.

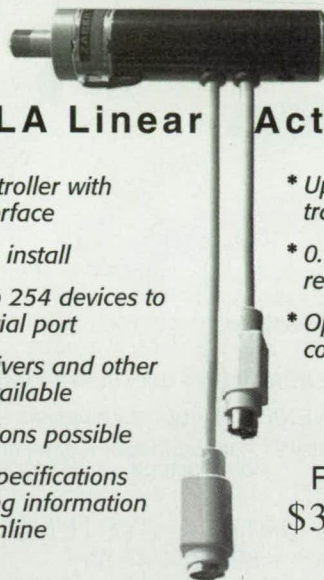
Unlike programs for designing refractive optics, AMPERES is based completely on wave optics (as distinguished from ray optics). The optimization-engine part of AMPERES is founded on reciprocity of electromagnetic propagation, utilizing a conceptual framework of constrained Lagrangian dynamics.

AMPERES produces designs for kinoform phase templates for fan-out gratings, radial phase elements, two-dimensional holograms, and refractive correctors for single thick lenses. A unique aspect of the refractive-correction module of AMPERES is that this module even treats thick refractive lenses in the wave-optics regime.

## AUTOMATED SUBMICRON POSITIONING



Automate your setup easily and affordably - replace manual micrometer heads with Zaber's T-LA Series of computer controlled linear actuators.

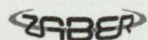


### The T-LA Linear Actuator

- \* Built-in controller with RS-232 interface
- \* No cards to install
- \* Chain up to 254 devices to a single serial port
- \* LabView drivers and other software available
- \* Customizations possible
- \* Complete specifications and ordering information available online

- \* Up to 60 mm travel
- \* 0.1  $\mu$ m resolution
- \* Optional control knob

FROM  
\$399 US



**ZABER Technologies Inc.**

info@zaber.com Tel: 1-866-409-2237 Fax: 604-648-8033

**www.zaber.com**

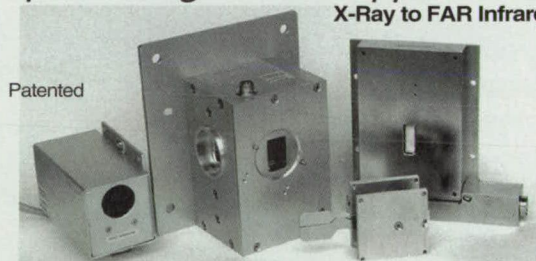
For Free Info Circle No. 486 or  
Enter No. 486 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

## LASER SHUTTERS

MODULATION / EXPOSURE  
SAFETY INTERLOCKS

*Specializing in OEM Applications*

X-Ray to FAR Infrared



*A single flexing blade element eliminates reliability concerns. Rapid switching speeds. Programmable modulation. Near zero backscatter. Models for CW and hi-power pulsed. Conduction and water cooled. Lifetimes exceeding 1 billion cycles.*

**nm Laser Products, Inc.**  
The Source for Laser Shutters™

Sunnyvale, California

Phone 408-733-1520 FAX 408-736-1152

Web Site: **www.nmlaser.com**

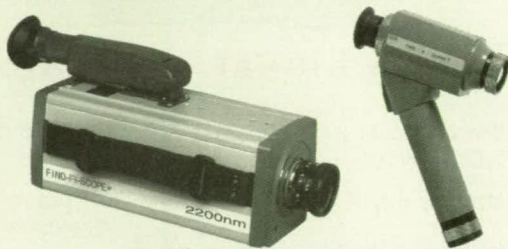


# FIND-R-SCOPE

## INFRARED VIEWERS

## ULTRA VIOLET VIEWERS

## INFRARED VIEWER/CAMERAS



**PERFORMANCE** - CUSTOM DESIGNED OPTICS  
UV or IR COATED

**DEPENDABILITY** - ONLY UL APPROVED VIEWER

**CONVENIENCE** - MODULAR DESIGN

**OPTIONS** - FOR MICROSCOPY, DARK ROOM,  
CCD, VIDICON, 180nm TO 2200nm

**FJW OPTICAL SYSTEMS, INC.**  
800-854-4FJW

629 S. Vermont St. Palatine, IL 60067  
847-358-2500 Fax: 847-358-2533

www.fjwopticalsystems.com e-mail: fjwopt@concentric.net

For Free Info Circle No. 444 or  
Visit [www.nasatech.com/444](http://www.nasatech.com/444)

## The Perfect Match

### The Fused Quartz Solution for Telecom Ferrules and Sleeves

- Thermal expansion coefficient and hardness closely match fiber properties
- Higher strength and purity: resists splitting, chipping & cracking with improved UV curing
- Smooth, consistent ferrules
- Variety of complex configurations: dual bore, rectangular, sleeves
- Excellent epoxy cure & bond
- Pigtail assemblies and custom cabling to meet your specifications



**Polymicro Technologies, LLC**

18019 North 25th Avenue • Phoenix, Arizona 85023-1200

Phone: 602-375-4100 • Fax: 602-375-4110

URL: <http://www.polymicro.com> • E-Mail: [sales@polymicro.com](mailto:sales@polymicro.com)

AMPERES generates phase templates with 128x128-pixel resolution. The template phase-profile designs can be either continuous or quantized (binary) with 2, 4, 6, 8, or 16 levels. Diffraction-plane images are produced for all designs. AMPERES is completely menu-driven. The interface for design input is graphical. Any stored results can be redisplayed by use of a viewer software module.

Computation by AMPERES is rapid, efficient, and accurate. The program can be executed on a common desktop personal computer.

*This work was done by S. Enguehard and B. Hatfield of Applied Mathematical Physics Research, Inc., for Marshall Space Flight Center. For further information, contact the company at (781) 862-6357 or access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to*

*Applied Mathematical Physics Research, Inc.*

*420 Bedford Street*

*Suite 230*

*Lexington, MA 02420*

*Refer to MFS-31428, volume and number of this NASA Tech Briefs issue, and the page number.*

## Ring-Resonator/Bragg-Grating Laser-Feedback Elements

**Semiconductor-laser spectral lines would be rendered narrow enough for metrology.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Integrated optical structures that contain ring resonators and Bragg gratings have been proposed as external feedback elements for semiconductor lasers. These feedback elements would constrain the laser spectra to narrow lines (more precisely, narrow spectral bands) centered at desired wavelengths. In the original intended applications, these feedback elements and the associated lasers would be constructed and operated in pairs to generate pairs of spectral lines separated by known wavelength intervals in the approximate range of 1 to 10 nm, as needed to resolve integer-multiple-of-wavelength ambiguities in laser metrology.

A ring resonator according to the proposal (see figure) would include a ring optical waveguide comprising a core of SiON (index of refraction = 1.483) and a cladding of SiO<sub>2</sub> (index of refraction = 1.463), formed on a substrate of Si by use of plasma-enhanced chemical vapor deposition. The resonator would also include two straight waveguides — one for input and one for output. The straight waveguides would be laid out in proximity to the ring waveguide, so that light would be coupled between the straight and ring waveguides via the evanescent-wave interaction. The overall operation of the resonator, in terms of transmissivity between ports 1 and 2 as a function of wavelength, would be similar to that of a Fabry-Perot etalon: the transmissivity spectrum would contain multiple sharp resonance peaks reminiscent of a comb.

A Bragg grating would be incorporated into one of the straight waveguides to select one of the ring resonances. To be effective for this purpose, the Bragg grating must be designed and fabricated to have a reflectance peak narrower than twice the free spectral range of the resonator — that is,



# Holiday Gift Ideas

from the publisher of *NASA Tech Briefs*

For fastest service order online at [www.nasatech.com/store](http://www.nasatech.com/store)



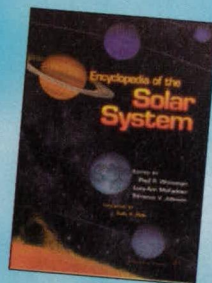
## Space Flight Patches — Collector's Edition Poster

High-quality 22" x 28" wall poster features mission patches from every manned space flight — Mercury, Gemini, Apollo, Skylab, and the Space Shuttles...141 in all! \$10.95



## NASA Logo Sweatshirt

NASA vector logo on quality white cotton sweatshirt. Available in adult medium, large, and extra-large sizes. \$19.95



## Encyclopedia of the Solar System

Four decades of the most exciting explorations in human history in one book! Superbly illustrated with full-color images from the Hubble Telescope and other spacecraft. Hardcover. 992 pages. \$96.95



## Two-Tone NASA Cap

Official NASA logo stitched on a Khaki/Navy brush cotton cap. Features a tuckaway matching fabric size adjuster with antique brass closure. One size fits all. \$14.95



## NASA Poster Set

Three 16" x 20" posters suitable for framing: Shuttle Endeavour Launch, View of Earth from Space, and Astronaut Space Walk. \$17.95 (Also available individually for \$6.95 each at [www.nasatech.com/store](http://www.nasatech.com/store))



## 2002 NASA Calendar

Each month features a striking, colorful space photo — Shuttle launches, astronauts in action, planets, and more. Includes historic dates in space flight and NASA facts. Special bonus: a complete photo collection of all human space flight patches. Fun and educational! \$9.50

Rush me:

(list quantity)

☐ Encyclopedia of the Solar System (\$96.95)

☐ NASA Poster Set (\$17.95)

☐ 2002 NASA Calendar (\$9.50)

☐ Two-Tone NASA Cap (\$14.95)

☐ Space Flight Patches Poster (\$10.95)

☐ NASA Logo Sweatshirt (\$19.95)

Circle size(s): M L XL

Add \$6.00 to order for postage and handling. NY residents add sales tax.

Total: \$ \_\_\_\_\_

☐ Check enclosed (payable to ABP International)

☐ Charge my: ☐ VISA ☐ Mastercard ☐ AmEx

Account No. \_\_\_\_\_ Expire Date \_\_\_\_\_

Signature \_\_\_\_\_

Name \_\_\_\_\_

Company (if not home address) \_\_\_\_\_

Address \_\_\_\_\_

City/St/Zip \_\_\_\_\_

Phone No. \_\_\_\_\_ E-mail \_\_\_\_\_

Mail to: ABP International, Dept. F, 317 Madison Avenue, #1900, New York, NY 10017

Fax to: (212) 986-7864 Questions? E-mail [kenny@abptuf.org](mailto:kenny@abptuf.org).



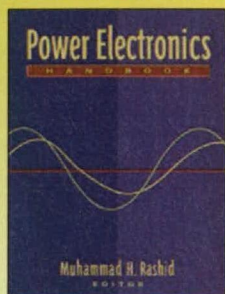
## UNDERSTANDING PHOTOMULTIPLIERS

New brochure provides information on the principle of operation, performance characteristics, and applications of photomultipliers. The publication also illustrates the attributes of various pmt structures as well as an in-depth analysis of output data. Electron Tubes manufactures a full line of photomultipliers and light detector assemblies and provides technical and sales assistance to the photodetection OEM and research community. For information or assistance, please visit us at [www.electrontubes.com](http://www.electrontubes.com), call 800-521-8382, or e-mail us at [sales@electrontubes.com](mailto:sales@electrontubes.com).

### ELECTRON TUBES INC.

For Free Info Circle No. 446 or  
Enter No. 446 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

## Power Electronics

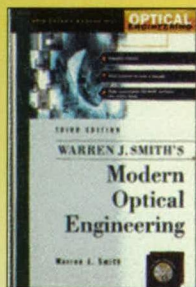


### Handbook

The first concise yet comprehensive reference book on power electronics and its applications. Expert coverage of power semiconductor devices, power converters, and much more. Hardcover, 35 chapters. **Introductory price: \$146.00.**

Order online:

[www.nasatech.com/store](http://www.nasatech.com/store)



## Modern Optical Engineering

**NEW Third Edition**

The book that both experts and neophytes turn to first, Warren J. Smith's revered text is now updated with the latest applications, tools, and techniques — plus

new insights from the master. Includes electronic version of the complete book on CD-ROM. Hardcover \* 617 pages \* \$80.00.

Order online:

[www.nasatech.com/store](http://www.nasatech.com/store)

## Mechanical Engineer's Handbook



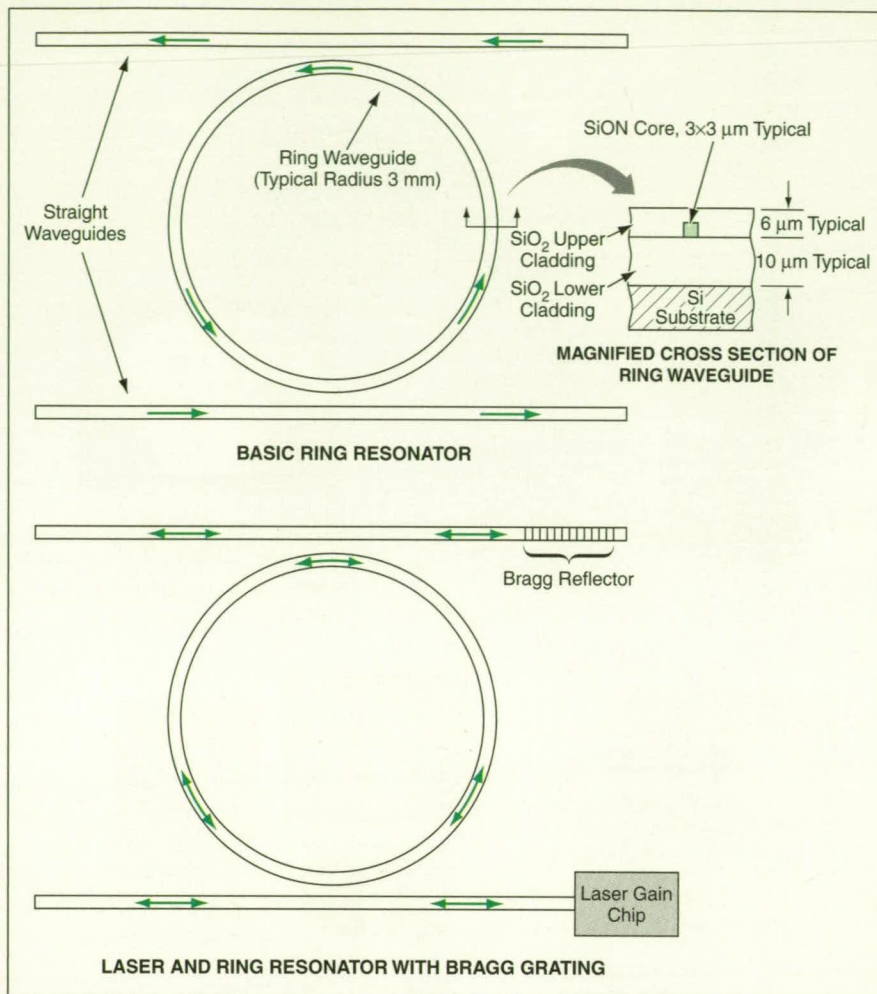
An essential companion for the mechanical engineer. With over 1,000 pages, 550 illustrations, and 26 tables, the Mechanical Engineer's Handbook is comprehensive yet affordable and portable. It covers all major areas of mechanical engineering & design with succinct definitions, formulas, and examples.

**Hardcover • 1,100 pages**  
**Introductory price: \$67.95**

Order online:

[www.nasatech.com/store](http://www.nasatech.com/store)

## Photonics Tech Briefs



A Ring Resonator and Bragg Reflector, combined into an integrated optical feedback structure, is expected to enable a semiconductor laser to generate a spectrum much narrower than it otherwise would.

narrower than double the spectral interval between successive resonance peaks. It would also be necessary to match the transmission pass band of the grating with one of the resonance peaks. An electric-heater element could be deposited on the ring or on the grating for this purpose: selective heating of the ring or grating could vary the resonance peaks or the pass band to effect this match.

For an example involving a wavelength of  $1.55 \mu\text{m}$ , ring radius of 3 mm, and propagation loss of 0.2 dB/cm, the resonance quality factor ( $Q$ ) was estimated to be  $10^5$ . Assuming further that the requirements stated in the preceding paragraph were satisfied, that the reflectivity of the Bragg-grating in the vicinity of one of the ring resonances was about 0.97, and that the interface reflectivity was 3 percent, it was estimated that laser gain chip that would ordinarily emit a spectral line 50 MHz wide when operated by itself would emit a spectral line with a width of 10 kHz or

less when operated with this feedback structure connected to it. A width of 10 kHz is comparable to the spectral widths of neodymium-doped yttrium aluminum garnet (Nd:YAG) lasers used heretofore in metrology.

*This work was done by Alexander Ksendzov of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to*

*Intellectual Property group*

*JPL*

*Mail Stop 202-233  
4800 Oak Grove Drive  
Pasadena, CA 91109  
(818) 354-2240*

*Refer to NPO-21189, volume and number of this NASA Tech Briefs issue, and the page number.*





## STAY ON THE CUTTING EDGE

Renew or get your own copy of *NASA Tech Briefs*. You can qualify at our website:  
**www.nasatech.com/subscribe** or Fax this form to **856-786-0861**

Please print

Reader ID Number 000 | | | | | | | |

Name \_\_\_\_\_

Title \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

City/St/Zip \_\_\_\_\_

Check one of the following:

☐ New Subscription

☐ Renewal

☐ Change of address

For Change of Address and/or Renewal you must provide the 11-digit Reader ID Number from your mailing label.

You can also mail this form to:

*NASA Tech Briefs*  
P.O. Box 10523  
Riverton, NJ 08076-9023

**1** Do you wish to receive (continue to receive) *NASA Tech Briefs*? ☐ Yes ☐ No

Please check preferred format:

a. ☐ Print Version of *NASA Tech Briefs* only

b. ☐ Digital (PDF) Version of *NASA Tech Briefs* only

c. ☐ BOTH the Print AND Digital (PDF) Versions of *NASA Tech Briefs*\*

Signature \_\_\_\_\_ Date \_\_\_\_\_

Bus. Tel. No. \_\_\_\_\_ Bus. Fax No. \_\_\_\_\_

e-mail \_\_\_\_\_

\*If you checked "c" above that you wish to receive BOTH the Print and Digital Versions of *NASA Tech Briefs*, there is a small service fee of \$2.00 per month (\$24 annually).

☐ My check (for \$24) is enclosed

☐ Bill me

☐ Charge to my:

☐ American Express

☐ Discover Card

☐ Master Card

☐ Visa

Card # \_\_\_\_\_

Exp. Date \_\_\_\_\_

Signature \_\_\_\_\_

**2** Which of the following best describes your industry or service? (check one)

E ☐ Electronics

S ☐ Computers

X ☐ Communications

O ☐ Automotive

T ☐ Transportation

M ☐ Materials/Chemicals

P ☐ Power/Energy

B ☐ Bio/Medical

J ☐ Consumer Product Manufacturing

Q ☐ Industrial Machinery & Equip.

A ☐ Aerospace

G ☐ Government

D ☐ Defense

R ☐ Research Lab

U ☐ University

Z ☐ Other (specify): \_\_\_\_\_

**5 a.** In which of the following categories do you recommend, specify, or authorize the purchase of products? (check all that apply)

01 ☐ Electronics

02 ☐ Photonics

03 ☐ Computers/Peripherals

04 ☐ Software

05 ☐ Mechanical Components

06 ☐ Materials

07 ☐ None of the above

**5 b.** Products you recommend, specify, or authorize for purchase: (check all that apply)

32 ☐ ICs & semiconductors

33 ☐ Connectors/interconnections/packaging/ enclosures

02 ☐ Board-level products

18 ☐ Sensors/transducers/detectors

16 ☐ Data acquisition

19 ☐ Test & measurement instruments

34 ☐ Power supplies & batteries

35 ☐ PCs & laptops

06 ☐ Workstations

36 ☐ EDA/CAE software

37 ☐ CAD/CAM software

17 ☐ Imaging/video/cameras

38 ☐ Lasers & laser systems

39 ☐ Optics/optical components

40 ☐ Fiber optics

41 ☐ Optical design software

20 ☐ Motion control/positioning equipment

30 ☐ Fluid power and fluid handling devices

31 ☐ Power transmission/motors & drives

42 ☐ Rapid prototyping and tooling

13 ☐ Metals

28 ☐ Plastics & ceramics

27 ☐ Composites

43 ☐ Coatings

80 ☐ None of the above

**6** How many engineers and scientists work at this address? (check one)

A ☐ 1

F ☐ 100-249

B ☐ 2-5

G ☐ 250-499

C ☐ 6-19

H ☐ 500-999

D ☐ 20-49

J ☐ over 1000

E ☐ 50-99

**7** To which of the following publications do you subscribe? (check all that apply)

01 ☐ Cadalyst

02 ☐ Cadence

03 ☐ Computer-Aided Engineering

05 ☐ Designfax

06 ☐ Design News

07 ☐ Desktop Engineering

08 ☐ EDN

09 ☐ Electronic Design

10 ☐ Machine Design

11 ☐ Mechanical Engineering

12 ☐ Product Design & Development

13 ☐ Sensors

14 ☐ Test & Measurement World

15 ☐ Laser Focus World

16 ☐ Photonics Spectra

17 ☐ None of the above

**3** Your engineering responsibility is: (check one)

A ☐ Manage Engineering Department

B ☐ Manage a Project Team

C ☐ Manage a Project

D ☐ Member of a Project Team

E ☐ Other

(specify) \_\_\_\_\_

**4** Your job functions are:

(please check all that apply)

10 ☐ Design & Development Engineering (Inc. applied R&D)

12 ☐ Testing & Quality Control

13 ☐ Manufacturing & Production

14 ☐ Engineering Management

16 ☐ General & Corporate Management

17 ☐ Basic R&D

15 ☐ Other (specify)

Write in the number of your principal job function \_\_\_\_\_

**8** Would you like to receive a free e-mail newsletter from *NASA Tech Briefs*?

☐ Yes ☐ No

Your e-mail address \_\_\_\_\_

You may receive renewal reminders via e-mail. Do you want to receive other business-to-business third party e-mail offers from *NASA Tech Briefs*?

☐ Yes ☐ No



# New Products

## PRODUCT OF THE MONTH



For Free Info Circle No. 730 or Enter No. 730 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

### Fiber Network Link Certification

Tempo, Camarillo, CA, announces its RIFOCS MT-RJ fiber optic link certification product line. The line encompasses palm-size testing products such as the 556MT optical power meter, the 255MT 1300-nm LED light source, and the complementary 263MT visual fault finder. An 850-nm LED source, the RIFOCS 257MT, is also available. Breaks in optical links as well as connector loss problems, splices, and blends in the cabling can be isolated along the cable route. The visual fault finder's red laser visually verifies end-to-end continuity and helps to pinpoint problems. The RIFOCS fiberTOOL® test equipment is available both in test set kits as well as individual units.



### Workstations for Vibration Isolation

The family of vibration isolation products from Kinetic Systems, Boston,

MA, includes a line of workstations for personal, midrange, and heavy-load configurations. The company says all designs provide a vibration-controlled work environment with low natural frequencies and high vertical and horizontal isolation efficiencies. The Personal Workstations are designed for small labs and tight spaces, and will accommodate loads up to 440 lbs. The larger midrange designs can control loads up to 1300 lbs., and the heavy-load models 2800 lbs.

For Free Info Circle No. 732 or Enter No. 732 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

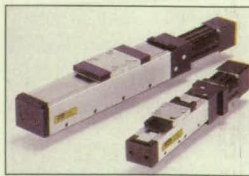


### SONET-Compliant Optical Transceiver

Stratos Lightwave, Chicago, IL, makes available a family of SONET-compliant small-form-

factor (SFF) optical transceivers. Versions for OC-48 (2.488 Gb/s), OC-12 (622 Mb/s), or OC-3 (155 Mb/s) are available. Featuring a 2- by 10-pin configuration, the high-density transceivers are designed for the next generation of metropolitan area networking and telecommunications, according to Stratos. They feature TTL signal detect output and transmitter disable input. The devices operate at 1310 nm with single-mode cable and industry-standard FC connectors.

For Free Info Circle No. 735 or Enter No. 735 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



### Miniature Positioners

The new 401XR and 402XR miniature positioning tables from Parker Hannifin's Daedal

Division, Irwin, PA, are only 1.6 in. and 2.3 in. wide. Standard features are protective strip seals, precision-ground ballscrew, and high-strength recirculating bearing system. Modular options include non-contact linear encoders with resolutions to 0.1 micron and several connectorized limit and home sensors. The XR tables are configured with selectable motor block and couplings to accept any industry-standard servo or step motor.

For Free Info Circle No. 738 or Enter No. 738 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



### Nd:YAG DPSS Laser

Cutting Edge Optonics, St. Charles, MO, has introduced the Scimitar™ laser, a 1064-

nm Nd:YAG diode-pumped solid-state instrument that can produce 150 W multimode or 20 W TEM<sub>00</sub>. The Scimitar is equipped for continuous-wave or acousto-optic Q-switch operation from 1 to 50 kHz, and it also has a green output option, producing up to 35 W at the 532-nm wavelength. The company says that applications for the Scimitar include micromachining, welding, cutting, ablating, drilling, fast laser marking, engraving and sintering.

For Free Info Circle No. 733 or Enter No. 733 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

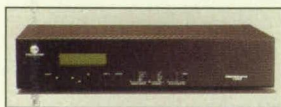


### Laser Sensor for Glass Thickness Measurement

LMI Selcom, Detroit, MI, is offering a Class II visible laser sensor and

controller capable of measuring flat glass thickness and profile at a speed of 2000 readings per second. The Glass Thickness Sensor (GTS) sends a laser beam onto the glass at an angle of 49 degrees from perpendicular. The laser light appears on both sides of the glass being measured and reflects back into a sensor/detector. The GTS measures glass thickness from 0.3 mm to 4 mm at a standoff distance of 26-30 mm. LMI Selcom suggests applications would include LCD glass, medical glass, digital video disks, and fluorescent chips.

For Free Info Circle No. 736 or Enter No. 736 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



### Video Scan Converter

RGB Spectrum, Alameda, CA,

adds the Model 1690 to its RGB/Videolink® family of video scan converters. It accepts interlaced or noninterlaced RGB inputs from virtually any workstation or desktop computer. The unit synchronizes to all computer signals with screen resolutions up to 1600 × 1280 pixels and with scan rates from 15 kHz to 90 kHz. As outputs, the device offers NTSC/PAL composite video, S-Video, and component analog video. Digital signal processing circuitry is used to eliminate interlace flicker in the output image. SMPTE 259M digital output is available as an option.

For Free Info Circle No. 739 or Enter No. 739 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



### Laser Sensor for Edge Detection

Automatic Timing and Controls, Lancaster, PA, introduces the Model 7703AR04N3BQP laser sensor, a compact Class 2 device in a rugged housing. It offers both proximity and reflective mode sensing.

Light Operate and Dark Operate are user selectable, with an adjustable power potentiometer. The sensor can be connected for either NPN or PNP output, and operates from 10 to 30 VDC. The unit's spot size is less than 1 mm at 2 feet, with little divergence over distances up to 160 feet, according to the company.

For Free Info Circle No. 731 or Enter No. 731 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



### Telecentric Lenses for Machine Vision

LINOS Photonics, Milford, MA, is offering a standard line of telecentric lenses for

industrial machine vision applications. The company says the lenses are insensitive to small variations of the object distance, have high resolution and low distortion, and are of a robust mechanical design. They are designed for an object distance of 250 mm (9.75 in.) and for 2/3-in., 1/2-in., and 1/3-in. CCD camera formats, and optimized for maximum object diagonals of 25 mm and 50 mm. For wavelength matching, the lenses have a standard M 67 × 0.75 filter threads.

For Free Info Circle No. 734 or Enter No. 734 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



### Carbon Dioxide Laser Lenses

Laser Research Optics, Providence, RI, offers a broad range of carbon dioxide laser lenses and windows for use in industrial and medical lasers. The lenses are available from 0.6 in. to 2.0 in. diameters,

and focal lengths from 1 in. to 20 in. in 0.1-in. increments, depending upon configuration, and in sizes up to 3.0 in. in diameter for use as windows. Suitable for laser systems from 25 to 200 W, the zinc selenide positive-focusing lenses provide less than 0.25 percent total absorption values.

For Free Info Circle No. 737 or Enter No. 737 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



### Broadband Infrared Spectral Radiometer

Electro-Optical Industries, Santa Barbara, CA, introduces the Model RSA2000-CVF infrared spectral radiometer. The company says the unit was

designed with optics with diameters of 8 in. to enhance sensitivity, and a circularly variable filter for high-resolution spectral analysis. The cryoengine-cooled dual detector enables wide spectral response of 1.4 to 14 microns with less than 1 percent lambda spectral resolution. The color-corrected Cassegrain telescope has four fields of view: 2.5 mrad, and 2, 5, and 10 degrees.

For Free Info Circle No. 740 or Enter No. 740 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## Relatively Simple Atmospheric-CO<sub>2</sub> Controller

Temperature of an alkanolamine solution is controlled to make it absorb or desorb CO<sub>2</sub>.

Lyndon B. Johnson Space Center, Houston, Texas

An apparatus has been developed as a means of controlling the partial pressure of CO<sub>2</sub> ( $p\text{CO}_2$ ) in air in a closed or semi-closed environmental system. The apparatus takes CO<sub>2</sub> from the air in a source chamber and supplies the CO<sub>2</sub>, at a regulated partial pressure, to the air in a sink chamber. In the original intended application, the chambers would be located aboard a spacecraft: the source chamber would be inhabited by crewmembers, and the sink chamber would be a plant-growth chamber. Apparatuses like this one could also be used to control  $p\text{CO}_2$  in research plant-growth chambers on Earth.

In comparison with prior  $p\text{CO}_2$ -regulating apparatuses built around sources of compressed gases, mass-flow controllers, CO<sub>2</sub> sensors, and/or single-use sorbents, this apparatus consumes less expendable material and is relatively simple and inexpensive. In this apparatus (see figure), CO<sub>2</sub> is gathered from the source atmosphere, across a semipermeable membrane, into a reservoir that contains an aqueous solution of an alkanolamine. Depending on conditions,

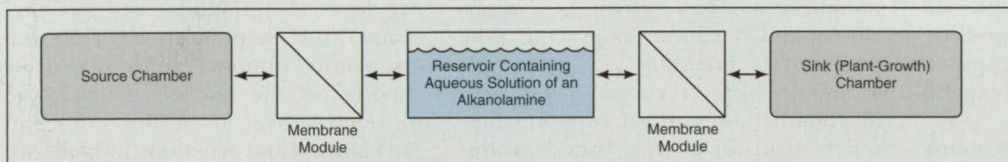
such a solution absorbs or desorbs CO<sub>2</sub>; the CO<sub>2</sub> load in the solution depends on the  $p\text{CO}_2$ , duration of exposure, and temperature. From the solution, CO<sub>2</sub> is transferred, as needed, across another semipermeable membrane, to the atmosphere in the sink chamber. Because the release of CO<sub>2</sub> to the atmosphere in the sink chamber is an equilibrium process, the resulting  $p\text{CO}_2$  in the sink chamber depends on both the CO<sub>2</sub> loading of the alkanolamine and the temperature and can be controlled, within specified limits, by changing the temperature of the alkanolamine solution.

In the case of an inhabited source chamber, the  $p\text{CO}_2$  in that chamber can generally be expected to exceed the  $p\text{CO}_2$  required for a sink chamber in which plants are to be grown. In such a case, CO<sub>2</sub> can be gathered periodically from the source chamber to maintain the required CO<sub>2</sub> loading of the solution while the required  $p\text{CO}_2$  in the plant-growth chamber is maintained through equilibrium exchange. Because of the large CO<sub>2</sub> capacity of the alkanolamine, stable control of the  $p\text{CO}_2$  in the plant-growth chamber is easily achieved.

When the  $p\text{CO}_2$  in the source chamber is less than the  $p\text{CO}_2$  required in the sink chamber, temperature-dependent solubility is used to pump CO<sub>2</sub> against its concentration gradient: Inasmuch as the equilibrium  $p\text{CO}_2$  above the alkanolamine solution increases with temperature, CO<sub>2</sub> is gathered through the membrane on the source-chamber side at a temperature lower than that at which it is released through the other membrane on the plant-growth-chamber side.

The absorption of CO<sub>2</sub> in an alkanolamine solution takes place through reversible ionization reactions that change the relative abundance of electrically conductive species in the solution. As a result, there is a relationship between the electrical conductance of the solution and its CO<sub>2</sub> load. This relationship is exploited in the present apparatus: The electrical conductance measured at a given temperature is taken as an indication of the CO<sub>2</sub> loading of the solution and, by extension, of the equilibrium  $p\text{CO}_2$  of the atmosphere in contact with the solution.

*This work was done by Jeffrey L. DeHart, James R. Akse, and James E. Atwater of Umpqua Research Co. for Johnson Space Center. For more information, contact the Johnson Commercial Technology Office at (281) 483-3809. MSC-22911*



The Alkanolamine Solution in the Reservoir acts as a buffer for CO<sub>2</sub>: Its temperature is varied to make it store or release CO<sub>2</sub> as needed to maintain a required  $p\text{CO}_2$ .

## A Technique for Injecting Ag<sup>+</sup> Ions as Biocide into H<sub>2</sub>O

Lyndon B. Johnson Space Center, Houston, Texas

A simple and reliable technique facilitates the addition of silver ions to water supplies to suppress bacterial contamination. In the original application for which the technique was devised, there is a need for Ag<sup>+</sup>-ion concentrations at a biocidal levels (0.5 mg/L) in 44-L batches of drinking water. The technique involves the preparation of a solution of concentrated biocide by dissolving 0.66 g of AgF and 1.04 g of NaF in 0.5 L deionized

water. Batches of the solution are put into plastic syringes that have volumes of 20 cm<sup>3</sup> each and are equipped with fittings for connection to the water supplies to be treated. The syringes are capped and placed in plastic bags for transport and storage. The shelf life of the syringes stored at room temperature is at least two years. When needed, a syringe is simply unpacked and connected to a mating fitting on a water supply. The concentrated

solution is then injected into the flowing water, wherein the solution becomes diluted to the desired final concentration.

*This work was done by Richard L. Sauer of Johnson Space Center and Paul D. Mudgett and John R. Schultz of Wyle Laboratories. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Materials category. MSC-23170*





## ✱ Breathing-Air and Cooling Apparatus for Protective Suit

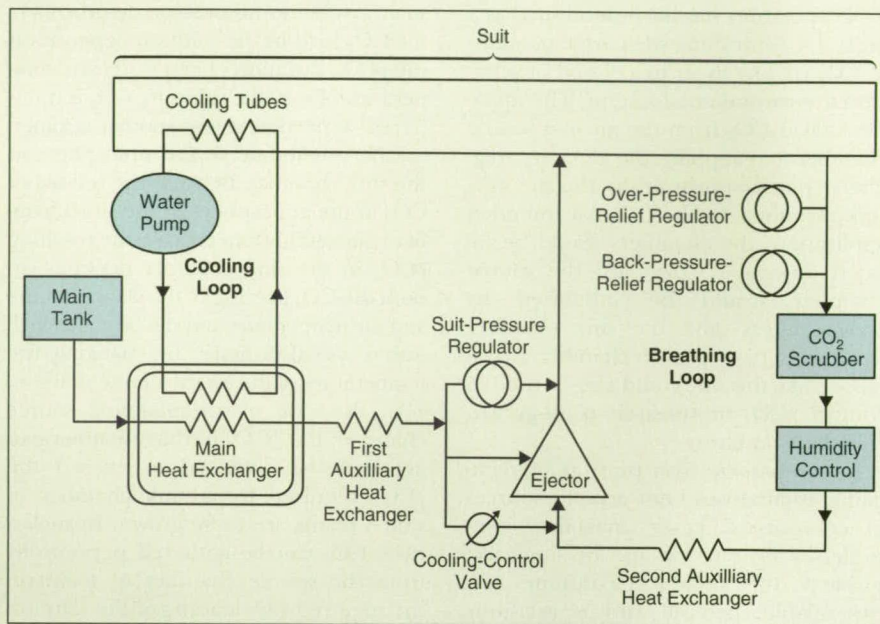
Applications can include diving, space, and firefighting suits.

Lyndon B. Johnson Space Center, Houston, Texas

The figure schematically illustrates a portable life-support apparatus for any of a variety of protective suits to be worn in hostile environments. A prototype of the apparatus has been fitted to space suits for use underwater. Astronauts wear these suits during training dives in a tank of warm water, using the neutral buoyancy available in the underwater environment to simulate aspects of the zero gravitation of outer space. The apparatus provides breathing air and adjustable cooling in the suit, while maintaining overall neutral buoyancy. The apparatus is readily adaptable to such related applications as conventional diving and space suits, firefighting suits, and protective garments to be worn in hot, toxic, and/or radioactive environments.

The apparatus is shown schematically in the figure. The source of both breathing air and cooling is a supply of liquid air inside part of the volume of an insulated tank. The part of the tank that contains the liquid air is separated from the rest of the tank by an insulated piston. The rest of the tank is pressurized, by use of a small cylinder of compressed gas, to a level greater than the pressure in the liquid air, so that the piston pushes against the liquid air to expel it from the tank as needed.

The apparatus includes a cooling loop, in which a pump circulates water between a main heat exchanger and cooling tubes in the protective suit. When liquid air flows from the tank, it passes through the heat exchanger, where it absorbs heat from the circulating water. Thus, in a single action, the main heat exchanger both removes the wearer's body heat from the circulating cooling water and uses this heat to help vaporize the liquid air and warm it to a breathable temperature. At the outlet of the main heat exchanger, the flowing air may be too cold to breathe, and some of it may still be in liquid form. Accordingly, the flow is then made to pass through a first auxiliary heat exchanger, where any remaining liquid fraction is vaporized and warmed to a breathable temperature.



The Cooling and Breathing Loops are both energized by the flow of liquid air expelled from the main tank by pressurized gas.

From the outlet of the first auxiliary heat exchanger, the air flows via one or more of three paths into the breathing-air loop, which is a semi-closed air-circulation loop. One flow path into the breathing loop is through a suit-pressure regulator that acts in conjunction with an over-pressure-relief regulator to maintain the desired pressure (to simulate suit pressure in a vacuum) in the suit. Another path is directly into an ejector, wherein the flow is formed into a high-speed jet, the momentum of which is then transferred to the immediately surrounding air to obtain a pumping action to circulate the air in the breathing loop without need for a blower with moving parts. The third path is through a cooling-control valve, which the wearer adjusts manually to adjust the overall rate of flow of air out of the main tank and thereby adjust the rate of cooling.

Within the breathing loop, the exhaled carbon dioxide is removed from the circulating air by use of a CO<sub>2</sub> scrubber. Exhaled and other excess

moisture is removed by a humidity-control unit, which is simply a bed of desiccant material. The breathing loop also includes an auxiliary temperature regulator, wherein the circulating atmosphere is selectively exposed to the ambient temperature to remove heat from the CO<sub>2</sub>- and H<sub>2</sub>O-absorption reactions, which are exothermic.

*This work was done by Bruce Caldwell of Oceaneering Space Systems for Johnson Space Center. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Machinery/Automation category.*

*Title to this invention, covered by U.S. Patent No. 5,365,745 has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)]. Inquiries concerning licenses for its commercial development should be addressed to*

*John C. Propeck  
Oceaneering Space Systems  
16665 Space Center Blvd.  
Houston, TX 77058*

*Refer to MSC-22442, volume and number of this NASA Tech Briefs issue, and the page number.*



# Thermoelectric Contact Cooler/Freezer

**This cooler is efficient and quiet.**

*Lyndon B. Johnson Space Center, Houston, Texas*

A thermoelectric contact cooler/freezer is designed to utilize thermal conduction to rapidly freeze blood and urine samples in test tubes and syringes. This apparatus is dependable, wastes little energy, contains no moving parts other than a fan, can operate in a wide temperature range and in any orientation (including in zero gravity), is quiet, and emits no chlorofluorocarbons or other greenhouse gases. It is a vast improvement over currently available convection-type cooler/freezers.

Convection-type cooler/freezers do not freeze samples as rapidly as do conduction freezers; this is a major consideration because if samples are frozen too slowly, then their integrity is threatened. Convection-type cooler/freezers are unreliable because they are best on the use of chlorofluorocarbon fluids and compressors; leaks can occur, contributing to the greenhouse effect, and the compressors are very noisy during operation. In addition, convection-type cooler/freezers are less efficient.

The thermoelectric contact cooler/freezer includes an aluminum two-part housing, a pair of cold plates, thermoelectric elements, a fan, and a temperature-control unit. The cold plates contain machined semicircular-cross-section grooves that constitute receptacles into which test tubes or syringes can be inserted. The plates are spring-loaded against each other to provide gentle clamping of, and thus thermal contact with, the tubes or syringes in the grooves. The thermoelectric elements are mounted on the cold plates and are attached to free-floating, finned, hot-side heat sinks.

The apparatus is powered by direct current, which causes the thermoelectric elements to transfer heat from the cold plates to the heat sinks. When this happens, the fan blows air over the heat-sink fins to dissipate the heat from the heat sink.

One of the attributes that makes this cooler/freezer attractive from an industrial perspective is that it can be

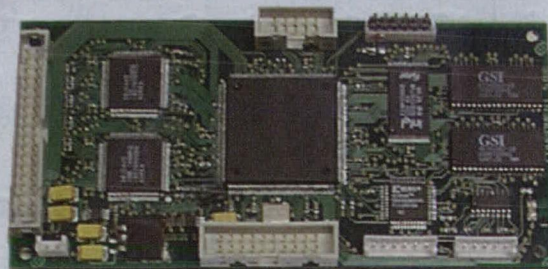
produced in various sizes. Small, lightweight portable units are now available. Thermoelectric contact cooler/freezers like this one have been proposed to be included as subassemblies of larger cooling/storage units required to perform quick freezing in outer space. Because of its energy efficiency, dependability, quietness, and environmental suitability, the thermoelectric contact cooler/freezer could prove useful in any setting in which rapid freezing is needed to maintain the integrity of samples — particularly in laboratories, hospitals, and clinics, as well as in the spacecraft environment for which it was developed.

*This work was done by James D. Moncrief of Johnson Space Center and Danny D. Demonbrun of G. B. Tech. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Machinery/Automation category.*

MSC-22631

## Over 1 Million recognitions/second on an embedded board

- \* 2 ZISC chips totaling 156 processing elements
- \* 1 FPGA Spartan II totaling 150,000 gates
- \* 1 Mb Memory
- \* Parallel port
- \* Evaluation software enclosed for image processing and vector classification
- \* Examples



\* Shipping and handling not included, Regular price \$890  
Offer valid until November 15, 2001

## Silicon Recognition, Inc.

Call now: (707) 765-6296, visit our website [www.silirec.com](http://www.silirec.com), e-mail: [sales@silirec.com](mailto:sales@silirec.com)





### Molten-Carbonate Electrolyzers for Making CO and O<sub>2</sub>

Molten-carbonate fuel cells would be operated in reverse.

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Electrochemical cells in which molten carbonates would serve as electrolytes have been proposed for use in electrolyzing CO<sub>2</sub>. The proposal was made in an effort to implement a concept of *in situ* resource utilization (ISRU) for the exploration of Mars; the basic idea is to generate CO (if needed as a fuel) and O<sub>2</sub> (for oxidizing fuel and/or for breathing) by electrolysis of CO<sub>2</sub> from the Martian atmosphere. On Earth, molten-carbonate electrolyzers could be used to make breathable O<sub>2</sub> for medical use, pure O<sub>2</sub> for oxidizing surfaces of semiconductor chips, and CO as a feedstock for synthesis of alcohols and hydrocarbons. In both terrestrial and spacecraft life-support systems, the electrolyzers could be used to regenerate breathable O<sub>2</sub> from CO<sub>2</sub>.

The proposed electrolyzers would amount in effect to molten-carbonate fuel cells optimized for operation in reverse. Solid-oxide electrolyzers (usually containing zirconia solid electrolytes) would be the closest competitors, were it not for their relative fragility, susceptibility to leakage, and necessity of very high operating temperatures. Sabatier systems would be the next closest competitors, except that hydrogen must be supplied for operation, making them impractical in the intended applications. Other would-be competitors include glow-discharge reactors, which must be powered with high voltages and currents; and reverse water-gas reactors, for which catalysts must be regenerated.

Molten-carbonate fuel cells have been investigated extensively, but not with re-

spect to reverse operation for electrolysis. It should be a simple matter to adapt a commercial off-the-shelf molten-carbonate fuel cell for initial experiments in electrolysis. Topics that must be addressed in efforts to develop molten-carbonate electrolyzers include stability of the electrolytes and extension of operating lifetimes, which are short. The use of modern materials, including stabilizers for the electrolytes, is expected to be an important part of the proposed development efforts.

*This work was done by Kumar Ramohalli and Gerald Voecks of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category. NPO-20468*

### Optical Liquids Catalog



Write or call for free catalog.

New catalog of specialty optical liquids features high-transmission, safe-handling, laser liquids, plus fused silica matching liquids, and specific refractive index liquids (1.300-2.11  $n_D$ ). Now includes comparative diagrams of glasses and optical liquids.

**Cargille**

**Cargille Laboratories Inc.**  
55 Commerce Road, Cedar Grove, NJ 07009  
973-239-6633 • Fax 973-239-6096

### Improved Spherical Energy Analyzer

*NASA's Jet Propulsion Laboratory, Pasadena, California*

An improved spherical energy analyzer (a type of electrostatic mass spectrometer) is under development for use in analyzing a beam of ions generated by a Hall thruster. The major improvement, relative to a commercial spherical energy analyzer, is the addition of a quadrupole stage (with refocusing electron optics) for separating ions of different charge states. The development work also includes efforts to make the instrument smaller and lighter than the

commercial version in order to make it possible to translate and rotate the instrument through the ion beam inside a vacuum chamber that contains the Hall thruster.

*This work was done by Dennis Fitzgerald and James Cooley of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category. NPO-21116*

### Redundant Oxygen-Deficiency Monitoring System

*John F. Kennedy Space Center, Florida*

An oxygen-deficiency monitoring system (ODMS) has been developed for a ten-room facility in which the use of large amounts of nitrogen and helium could cause an oxygen deficiency severe enough to be hazardous to personnel.

The ODMS comprises three subsystems, of which two monitor three rooms each, and one monitors four rooms. The ODMS generates alarms when the oxygen content of the air in a room falls below 19.5 mole percent. Each subsys-



tem includes transport pumps that draw air continuously from each room through two tubes. Each subsystem includes two oxygen analyzers equipped with sampling pumps, plus two programmable-logic controllers (PLCs) and associated hardware that control electrically actuated valves that admit small fractions of the transport flows to the oxygen analyzers. The PLCs cause the valves to connect the two oxygen analyzers to two different sampling tubes, and then to switch the connections to a different pair of sampling tubes after an interval of about 10 seconds, and so forth until the air from all sampling points has been monitored, and then the sequence repeats. If one sampling tube, oxygen analyzer, pump, or PLC fails, it can be repaired while the system continues to operate, albeit at a reduced rate.

*This work was done by Paul A. Mogan of Kennedy Space Center and Richard J. Hritz, Donald C. Young, Wayne E. Rutherford, Guy Naylor, and Francisco Lorenzo-Luaces of Dynacs Engineering Co., Inc. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category. KSC-12067*

## Thermal Detection of Gas in a Tube Containing Flowing Liquid

A decrease in temperature downstream of a heater would indicate intrusion of gas.

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A relatively simple thermal technique has been proposed to enable detection of bubbles of gas or bulk gas in a tube that is meant to contain a flowing liquid only. In a system in which gas cannot be tolerated, the technique could be used to trigger a shutoff valve downstream of a location where gas is detected.

The technique would involve the placement of a circumferential electrical heating element around the tube and a circumferential thermometer around the tube a suitable short distance downstream of the heating element. The thermometer reading would be indicative of the rate of transfer of heat from the heating element to the thermometer; this rate would depend on the temperature of the heater, the rate of convective transfer of heat between the tube and the fluid at the heater and thermometer locations, and the thermal capacity of the fluid in the tube. These variables and thus the thermometer reading would be affected by any gas that might be present.

A device to implement the technique could be fabricated by placing a thin layer of a dielectric material around the tube, sputtering a thin platinum coat over the dielectric, and patterning the platinum into narrow rings around the tube at two (or more for redundancy) positions along the tube. The upstream platinum ring would be operated as a heater and resistance thermometer, and the downstream platinum ring would be operated as a resistance thermometer. For a specific combination of heater temperature and rate of flow, the temperature sensed by the downstream resistance thermometer would include a component proportional to the transport of heat by thermal mass flow in the tube. Intrusion of gas into the tube would reduce the effective thermal mass density of the fluid in the tube, and the temperature read by the downstream resistance thermometer would decrease accordingly.

*This work was done by Frank T. Hartley of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category. NPO-20996*

## Single-Board Computers with Ethernet!

BL2010 shown  
3.43" x 4.15" x .82"  
(87 x 105 x 21 mm)

**\$199** qty. 1

**\$159** without Ethernet

- Simplify your next embedded design project with Z-World single-board computers. Value-priced with the features you need, these boards are programmed with industry-proven Dynamic C® (TCP/IP source provided royalty free). Our hardware and software integration saves you development time and cost.

### Our product line features:

- 10Base-T Ethernet •
- Up to 168 digital I/O •
- A/D and D/A •
- Up to 4 serial ports •
- Up to 512K SRAM/Flash •
- Battery-backed time/date clock •
- Operator interfaces/core modules •
- Program/debug via the Internet •

Order Z-World products online @

[www.zworld.com](http://www.zworld.com)

or call toll-free

**888.362.3387**



2900 Spafford Street • Davis, CA 95616

T: 530.757.3737 • F: 530.753.5141 • E: [zworld@zworld.com](mailto:zworld@zworld.com)

For Free Info Circle No. 422 or  
Enter No. 422 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

## Flex-Circuits hi-rel, high-density interconnection

A 3-dimensional approach  
to electronics packaging



Single layer to multilayer • MIL-P-50884C certified, all types

- Optional connectors & pins for simplified assembly
- Integral wire-wound inductive coils
- SMT-ready design • 0.003" lines/spaces

Replace hard wiring, connector systems & circuit boards to  
create smaller, more reliable electronic packages

- Avionics • Medical devices • Telecommunications
- Military radios • Panelized flex for pick & place

## MINCO

Minco Products, Inc.

7300 Commerce Lane / Minneapolis, MN 55432-3177 U.S.A.  
Tel: (763) 571-3121 / Fax: (763) 571-0927 / [www.minco.com](http://www.minco.com)

For Free Info Circle No. 424 or  
Enter No. 424 at [www.nasatech.com/rs](http://www.nasatech.com/rs)





## Books & Reports

### Theory of Formation-Flying Control for Multiple Spacecraft

A report presents the mathematical basis of a method of controlling multiple spacecraft flying in formation, subject to control constraints. The spacecraft are assumed to be equipped with relative-position-sensing, relative-velocity-sensing, and communication infrastructure, and with maneuvering actuators. The method involves a leader-following control scheme. A graph is used to represent the hierarchy of, and the data dependencies among, the leading and following spacecraft. Graph-theoretic concepts are shown to play a vital role in determining the basic properties of the leader-following control architecture; hence, changes in the hierarchy (represented by changes in the graph) translate directly to the required changes in control.

*This work was done by Fred Hadaegh and Mehran Mesbahi of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy*

*of the report, "Formation Flying Control of Multiple Spacecraft via Graphs, Matrix Inequalities, and Switching," access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Mechanics category.*  
NPO-20902

### Self-Organization Based on Quantum Entanglement

A report presents a theoretical study of communication among intelligent agents in the presence of quantum entanglement and the absence of classical (in the sense of non-quantum) communication channels. Several paradigms of self-organization based on quantum entanglement are introduced and discussed. These paradigms include inverse diffusion, transmission of conditional information, decentralized coordination, cooperative computing, competitive games, and topological evolution in active systems.

*This work was done by Michail Zak of*

*Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Entanglement-Based Self-Organization," access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Information Sciences category.*  
NPO-30192

### Onboard Estimation of Times of Periapsis During Aerobraking

A report proposes a technique for onboard updating of the orbital period of an aerobraking spacecraft in order to estimate the time of the next periapsis. The time of periapsis is nearly centered in the middle of the drag pass, and provides a convenient reference time for events in the sequence that controls the activities taking place onboard the spacecraft. Heretofore, updates of periapsis times have been computed on Earth on the basis of radio tracking data, then uplinked to the spacecraft. Onboard updating could increase operational efficiency and reduce costs by reducing the amount of ground and tracking support needed.

*This work was done by Daniel T. Lyons of NASA's Jet Propulsion Laboratory, Robert H. Tolson of George Washington University, and James Longuski of Purdue University. To obtain a copy of the report, "Simple Autonomous Timing Update During Aerobraking," access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Mechanics category.*  
NPO-30155

## THERMAL SUPERIORITY

...with excellent product quality and immediate application / design assistance available.

**Flexfoil Heaters . . .** Available in virtually any shape, size, and wattage. Operating temperature range from -320°F to 450°F. Power densities to 40W/sq. in.

### Temperature Sensors . . .

RTD's, Kapton surface sensors, thermocouples, & thermistors... wire wound & foil element construction... resistance densities to 5000Ω.

**Heater/Sensor Integration . . .** available to improve control, speed response, and extend heater life.

Call today for more information.  
(714) 890-0058 • FAX (714) 890-0788

**TransLogic**  
INCORPORATED

5641 Engineer Drive • Huntington Beach, CA 92649  
On the Web at: [www.translogicinc.com](http://www.translogicinc.com)

### Report on User's Guide for Monthly Vector Wind Profile Model

A report briefly describes a user's guide for a computer program that constructs vector wind profiles on the basis of a statistical model. The monthly vector wind profiles are meant to be used (1) to estimate wind-dispersion-related dispersions of critical aerodynamic loads and corresponding aerospace-ascent-vehicle design parameters and (2) to analyze effects of monthly wind-profile dispersions on ascent trajectories and to design ascent autopilot systems to correct for these effects. The user's guide is



also said to list output data to aid the user in the verification of test output.

This work was done by Stanley I. Adelfang of Computer Sciences Corp. for Marshall Space Flight Center. To obtain a copy of the report, "Users Guide for Monthly Vector Wind Profile Model," access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category.  
MFS-31431

### Experiments on Residual-Stress Bondline Failures in an RSRM

A report describes an experimental study undertaken to verify a finite-element mathematical model used to predict residual stresses and stress-induced failures in the adhesive interfacial layers (bondlines) that join phenolic liners to interior surfaces of metal housings of reusable solid rocket motors (RSRMs). The model reflects the three-dimensional complexity of the stress fields in question and includes time- and temperature-dependent constitutive and failure properties of the adhesive material, which exhibits nonlinear viscoelasticity.

This report was done by David E. Richardson, Bradley R. Hoskins, Theodore J. Lewis, and Alan V. Palumbos of Thiokol Corp. for Marshall Space Flight Center. To obtain a copy of the report, "Verification of Finite Element Predictions of Residual Stress Bondline Failures in a Full-Scale Test Article," please contact Jim Ekstrom at [james.ekstrom@Thiokol.com](mailto:james.ekstrom@Thiokol.com).  
MFS-31321

### Improved Micromachined Vaporizing-Liquid Microthruster

A report describes an improved micromachined vaporizing-liquid microthruster (VLM), now under development as a prototype of thrusters for microspacecraft. This thruster is of the resistojet type: the energy for vaporization and expansion of a propellant liquid is provided through electrical-resistance heating. A typical VLM of prior design, fabricated on a chip, was comparatively bulky and was energy-inefficient because much of the energy that should have gone into heating the propellant was wasted in heating the chip.

This work was done by David Bame, Indrani Chakraborty, Juergen Mueller, and Stephen Vargo of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Micro Machined Vaporizing Liquid Microthruster (VLM) with Superior

Thrust Vector Control and Increased Thermal Efficiency," access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Machinery/Automation category.  
NPO-21100

### Sizes of Surface and Capped $\text{In}_{0.6}\text{Ga}_{0.4}\text{As}$ /GaAs Quantum Dots

A report describes an experimental study of the sizes and concentrations of capped (buried) and surface  $\text{In}_{0.6}\text{Ga}_{0.4}\text{As}$ /GaAs quantum dots that were grown by metal-organic vapor deposition under the same conditions except for the inclusion or exclusion of capping. [ $\text{In}_{0.6}\text{Ga}_{0.4}\text{As}$ /GaAs quantum dots are lens-shaped islands (typically a few nanometers thick and tens of nanometers in diameter) of  $\text{In}_{0.6}\text{Ga}_{0.4}\text{As}$  grown on a GaAs substrate. As used here, "capping" signifies the growth of a layer of GaAs over the  $\text{In}_{0.6}\text{Ga}_{0.4}\text{As}$  islands.] In the experiments, the sizes of the capped  $\text{In}_{0.6}\text{Ga}_{0.4}\text{As}$ /GaAs islands were measured by transmission electron microscopy (TEM).

This work was done by Rosa Leon of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Adatom condensation and Quantum Dot sizes in  $\text{In}_{0.6}\text{Ga}_{0.4}\text{As}$ /GaAs (001)," access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category.  
NPO-21010

### Fuel Cell Would Generate Power From Martian Atmosphere

A report proposes the development of a thin-film fuel cell that would generate electric power from two minor constituents of the Martian atmosphere —  $\text{O}_2$  and CO. These compounds are generated continuously by photolysis of  $\text{CO}_2$ , the major constituent. The fuel cell would include a cathode and an anode made of catalysts suitable for the selective low-temperature electrochemical reduction of  $\text{O}_2$  and oxidation of CO, respectively. It would also include a hygroscopic gel electrolyte.

This work was done by Joseph Lewis and Christopher England of Caltech for NASA's Jet Propulsion Laboratory. To obtain a copy of the report, "Indigenous Martian Atmospheric Power (IMAP)," access the Technical Support Package (TSP) free on-line at [www.nasatech.com](http://www.nasatech.com) under the Physical Sciences category.  
NPO-30123

## The Leader in Advanced Composite Training

- Advanced Composite Structures: Fabrication and Damage Repair Phase 1, 2 and 3
- Composite Laminate Design
- Repair Analysis and Substantiation
- Design of Composite Structures
- Design and Analysis of Composite Structural Joints

Training at our Nevada or Georgia facility or yours.  
Contact us for a complete course catalog.

**[www.abaris.com](http://www.abaris.com)**  
**(800) 638-8441**

Abaris Training Resources, Inc.  
5401 Longley Lane, Suite 49  
Reno, NV 89511 USA  
(775) 827-6568 • Fax: (775) 827-6599  
e-mail: [info@abaris.com](mailto:info@abaris.com)



For Free Info Circle No. 425 or  
Enter No. 425 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

## Marketplace



**BERG**  
W. M. BERG, INC.  
PRECISION MECHANICAL COMPONENTS  
**Has the Solution!**  
for all your precision mechanical component needs, from Design Concept to Production and beyond!  
Order your free catalog today!  
**W.M. BERG, INC.**  
499 Ocean Ave.  
E. Rockaway, NY 11518  
Phone: 800-232-BERG  
Fax: 800-455-BERG  
[www.wmberg.com](http://www.wmberg.com)

For Free Info Circle No. 431 or  
Enter No. 431 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



Lake Shore's newest in precision thermometry

## DT-670 Series Silicon Diode Temperature Sensors

The best accuracy across the widest temperature range from 1.4 to 500 K of any silicon diode

A unique tolerance band that exceeds the accuracy of Platinum RTDs from 25 to 500 K

Lake Shore's rugged SD package designed to withstand repeated thermal cycling and minimize sensor self-heating

**LakeShore.**  
Lake Shore Cryotronics, Inc.  
toll free 1-800-394-2243  
e-mail sales@lakeshore.com

**www.lakeshore.com**

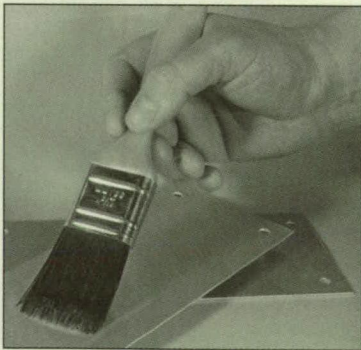
For Free Info Circle No. 426 or  
Enter No. 426 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

## NEW EPOXY HAS OUTSTANDING HEAT & CHEMICAL RESISTANCE

Glass Transition Temperature in Excess of 230°C

### MASTER BOND EP46HT-1

- Service temperature range exceeds 550°F
- Resists aggressive chemicals and solvents
- High physical strength properties
- Excellent adhesion to metallic and non-metallic substrates
- Outstanding electrical insulation
- Superior durability
- Remarkably high resistance to shock and vibration
- Unmatched dimensional stability
- 100% reactive - no solvents
- Easy cure schedules
- Convenient packaging



### Master Bond Inc. Adhesives, Sealants & Coatings

154 Hobart St., Hackensack, NJ 07601  
TEL: 201-343-8983 FAX: 201-343-2132

E-mail: [main@masterbond.com](mailto:main@masterbond.com)  
[www.MasterBond.com](http://www.MasterBond.com)

For Free Info Circle No. 427 or  
Enter No. 427 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

## New on the MARKET

### Product Development

IX SPeeD Suite™ from ImpactXoft Corp., San Jose, CA, combines digital modeling for mechanical design with tools for global design collaboration. The resulting Simultaneous Product Development is a way for members of development teams to co-develop products in parallel. Users can create, revise, and finalize digital product models together simultaneously, either in online or offline asynchronous mode. Changes can be merged and ideas exchanged over the Internet. The suite consists of IX Design digital modeling software for the Internet, and IX Collaboration server software that supports parallel co-design. **For Free Info Circle No. 724 or Enter No. 724 at [www.nasatech.com/rs](http://www.nasatech.com/rs)**



### Miniature Bellows Contacts

Servometer®, Cedar Grove, NJ, offers miniature bellows contacts for applications where contact with a delicate component or material is required. The contacts are rated for a maximum current of 4 amps. They minimize shock and vibration, and help to overcome tolerance buildup and misalignment problems. Servometer® contacts have low insertion forces, low insertion losses, and low DC resistance. **For Free Info Circle No. 720 or Enter No. 720 at [www.nasatech.com/rs](http://www.nasatech.com/rs)**

### Digital Recording System

The DGx™ digital recording system from RGB Spectrum, Alameda, CA, captures, compresses, and stores images up to 1280 x 1024 pixels. Computer, radar, video and audio acquisition, time-code, and event markers are supported. The unit accepts up to four image sources for recording to digital tape or disk. It digitizes inputs in real time and plays back from 6 to 25 frames per second, depending on image resolution. It can handle up to four images simultaneously which, on playback, can be displayed on one or two monitors. **For Free Info Circle No. 721 or Enter No. 721 at [www.nasatech.com/rs](http://www.nasatech.com/rs)**



### Visualization System

The RenderDrive™ RD5000 rendering system from Advance Rendering Technology, Mountain View, CA, uses physically accurate rendering methods to produce lifelike lighting, textures, and reflections on a variety of materials. It uses a silicon solution based on ray tracing to deliver 3D rendering. The system is platform and application independent, and can be used with Windows and UNIX platforms as well as 3D applications such as Solid Edge, SolidWorks, and Pro/ENGINEER. **For Free Info Circle No. 722 or Enter No. 722 at [www.nasatech.com/rs](http://www.nasatech.com/rs)**



### Data Visualization Software

Visual Numerics, Boulder, CO, has released PV-WAVE Version 7.5 software that allows engineers, researchers, and scientists to understand datasets using a variety of visual techniques. The software's interactive, array-based scripting language lets users develop platform-neutral applications for manipulating, analyzing, and visualizing datasets to detect and display trends, patterns, and anomalies. The software includes mathematical and statistical functions, image processing, signal processing, and general mapping functionality. **For Free Info Circle No. 723 or Enter No. 723 at [www.nasatech.com/rs](http://www.nasatech.com/rs)**



# Mass Spectrometers for Gas Analysis



process  
monitoring



research



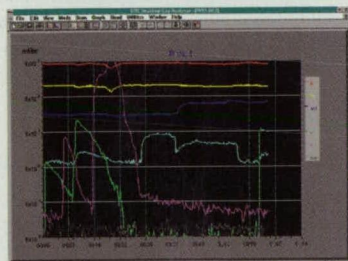
leak  
detection

- Response time of less than 1 second
- Compact, transportable design
- Large dynamic range allows detection to ppm levels
- Real-time Windows® analysis software
- Simple to setup and use

The QMS Series Gas Analyzers give you the power of on-line gas analysis and monitoring for a wide range of applications. These self-contained automated systems house a modern mass spectrometer for the analysis of light gases. You can detect leaks, measure gas composition and troubleshoot process lines.

The QMS system continuously samples gases, as opposed to batch sampling, which is utilized by gas chromatographs. This allows the QMS to detect gases at high speed – response time is less than 1 second. The inlet pressure can be configured to measure from vacuum to above atmospheric pressure.

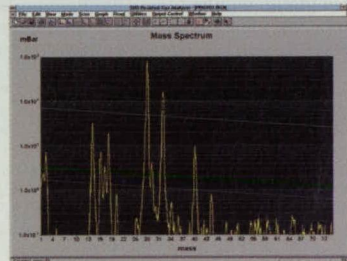
A Windows® based software package displays data in real-time and is included with each instrument. Offered as 100, 200 or 300 amu systems, one of our QMS Gas Analyzers will suit your application. Call SRS for a full brochure on the QMS or any of our other gas analysis instruments.



Pressure vs. time mode presents a strip chart display of partial pressures for selected gases and provides a complete history of data.

Helium	Water	Nitrogen	NO	Oxygen
9.3E-02	1.2E+01	5.9E+02	3.3E-01	1.3E+02
EXTREME LOW	12%	NORMAL	HIGH	NORMAL
Argon	CO2	CFC	OFF	OFF
1.0E+01	7.3E-01	1.3E-01	OFF	OFF
NORMAL	NORMAL	LOW		

Annunciator mode monitors up to 10 gases. User set limits allow Go/No-Go testing in conjunction with audible alarms and/or an optional relay board.



Analog mode presents the entire spectrum and displays the results as partial pressure vs. mass number. Gas monitoring can be continuous or timed.



Stanford Research Systems

1290-D Reamwood Avenue • Sunnyvale, CA 94089

Telephone: (408)744-9040 • FAX: (408)744-9049 • Email: [info@srsys.com](mailto:info@srsys.com) • WWW: <http://www.srsys.com>



# Call for Proposals

The U.S. Department of Energy (DOE) Small Business Innovation Research (SBIR) Program is providing funding for **Environmental Monitoring Technologies for Soils, Subsurface Sediments & Groundwater, Atmospheric Measurement Technology, and Carbon Cycle Measurements of the Atmosphere and the Biosphere**. Grant proposals are desired in the following areas:

- ◆ **Passive Microwave Radiometer for Water Vapor Measurements**
- ◆ **Characterization of Aerosol Organics**
- ◆ **Trace Gas Measurements**
- ◆ **Radiometric Instrumentation**
- ◆ **Sensors for Carbon Cycle Measurements**
- ◆ **Fiber Optic, Solid-State Chemical and Silicon Sensors**
- ◆ **Biosensors**

The detailed DOE-SBIR solicitation is available at the web site <http://sbir.er.doe.gov/sbir> or by calling **301-903-5707**.

Qualified U.S. small businesses are encouraged to apply. The closing date is January 15, 2002.

**For Free Info Circle No. 428 or Enter No. 428 at [www.nasatech.com/rs](http://www.nasatech.com/rs)**

## STATEMENT OF OWNERSHIP

U.S. Postal Service Statement of Ownership, Management, and Circulation (Required by 39 U.S.C. 3685) 1. Publication Title: NASA Tech Briefs 2. Publication No.: 1057-0411 3. Filing Date: 10/8/01 4. Issue Frequency: Monthly 5. No. of Issues Published Annually: 12 6. Annual Subscription Price: \$75.00 7. Complete Mailing Address of Known Office of Publication (Street, City, County, State and Zip+4) (Not printer): ABP International, Inc., 317 Madison Avenue, Suite 1900, New York, NY 10017-5391 8. Complete Mailing Address of Headquarters or General Business Office of the Publisher (Not Printer): ABP International, Inc., 317 Madison Avenue, Suite 1900, New York, NY 10017-5391 9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor. Publisher (Name and Complete Mailing Address): Joseph T. Pramberger, ABP International, Inc., 317 Madison Avenue, Suite 1900, New York, NY 10017-5391; Editor (Name and Complete Mailing Address): Linda Bell, ABP International, Inc., 317 Madison Avenue, Suite 1900, New York, NY 10017-5391; Managing Editor: None 10. Owner (if owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address as well as that of each individual must be given. If the publication is published by a nonprofit organization, its name and address must be stated). Full names and Complete Mailing Addresses: William Schnirring, Luke Schnirring, Melissa Schnirring, Domenic Muchetti, Joseph Pramberger, William Hague, all at ABP International, Inc., 317 Madison Avenue, Suite 1900, New York, NY 10017-5391 11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities. Full Name and Complete Mailing Address: None 12. For Completion by Nonprofit Organizations Authorized to Mail at Special Rates. The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes: Not applicable 13. Publication Name: NASA Tech Briefs 14. Issue Date for Circulation Data Below: September 2001 15. Extent and Nature of Circulation (Average No. Copies Each Issue During Preceding 12 Months/Actual No. Copies of Single Issue Published Nearest to Filing Date): a. Total No. Copies (Net Press Run): 206,191/204,725 b. Paid and/or Requested Circulation: (1) Sales through Dealers and Carriers, Street Vendors, and Counter Sales (Not Mailed): None/None (2) Paid or Requested Mail Subscriptions (Include Advertisers' Proof Copies/Exchange Copies): 197,920/198,442 c. Total Paid and/or Requested Circulation (Sum of 15b(1) and 15b(2)): 197,920/198,442 d. Free Distribution by Mail (Samples, Complimentary, and Other Free): 3,019/1,714 e. Free Distribution Outside the Mail (Carriers or Other Means): 2,703/2,442 f. Total Free Distribution (Sum of 15d and 15e): 5,722/4,156 g. Total Distribution (Sum of 15c and 15f): 203,642/202,598 h. Copies Not Distributed: 2,550/2,127 i. TOTAL (Sum of 15g and 15h): 206,191/204,725 Percent Paid and/or Requested Circulation (15c/15g x 100): 95.9/96.9% 16. This Statement of Ownership will be printed in the November 2001 issue of this publication. 17. I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties): Joseph T. Pramberger, Publisher.

# New LITERATURE

## Rugged Portable Workstation

A four-page brochure from FieldWorks, Eden Prairie, MN, details the features of its FW8000 Series Field WorkStation rugged portable computer that includes a Pentium® II processor, weather-resistant keyboard, and a choice of XGA or SVGA displays. The unit contains an internal and removable hard drive and sunlight-readable display. It provides connection for up to three full-length or six half-length ISA or PCI expansion cards. **For Free Info Circle No. 711 or Enter No. 711 at [www.nasatech.com/rs](http://www.nasatech.com/rs)**



## Polyurethane Foams

Crest Foam Industries, Moonachie, NJ, offers literature describing its FeltCrest™ compressed polyurethane foams for applications such as metering, wicking, gasketing, backing, cushioning, and sound absorption. The materials are available in a variety of compression ratios from 3 to 1 to 10 to 1. **For Free Info Circle No. 712 or Enter No. 712 at [www.nasatech.com/rs](http://www.nasatech.com/rs)**

## Sensing Systems

Oceana Sensor Technologies, Virginia Beach, VA, has released literature detailing sensing systems for applications such as machinery health monitoring. Intelligent component health monitors (ICHM™) provide information about pressure, oil condition, motor current, acoustic emission, vibration, temperature, and other operational functions. Other sensors are embedded in machinery to detect symptoms of deterioration and then transmit findings across a wired or wireless network to a system health monitor. **For Free Info Circle No. 713 or Enter No. 713 at [www.nasatech.com/rs](http://www.nasatech.com/rs)**



## Sockets and Interconnects

A brochure from Andon Electronics Corp., Lincoln, RI, highlights IC sockets, adapters, interconnects, and contact/terminal products. Featured are BGA Rollerball™ Sockets for PCB coplanarity assembly. Also featured are test solutions and probes, and jumpers, pin headers, and receptacles. **For Free Info Circle No. 714 or Enter No. 714 at [www.nasatech.com/rs](http://www.nasatech.com/rs)**

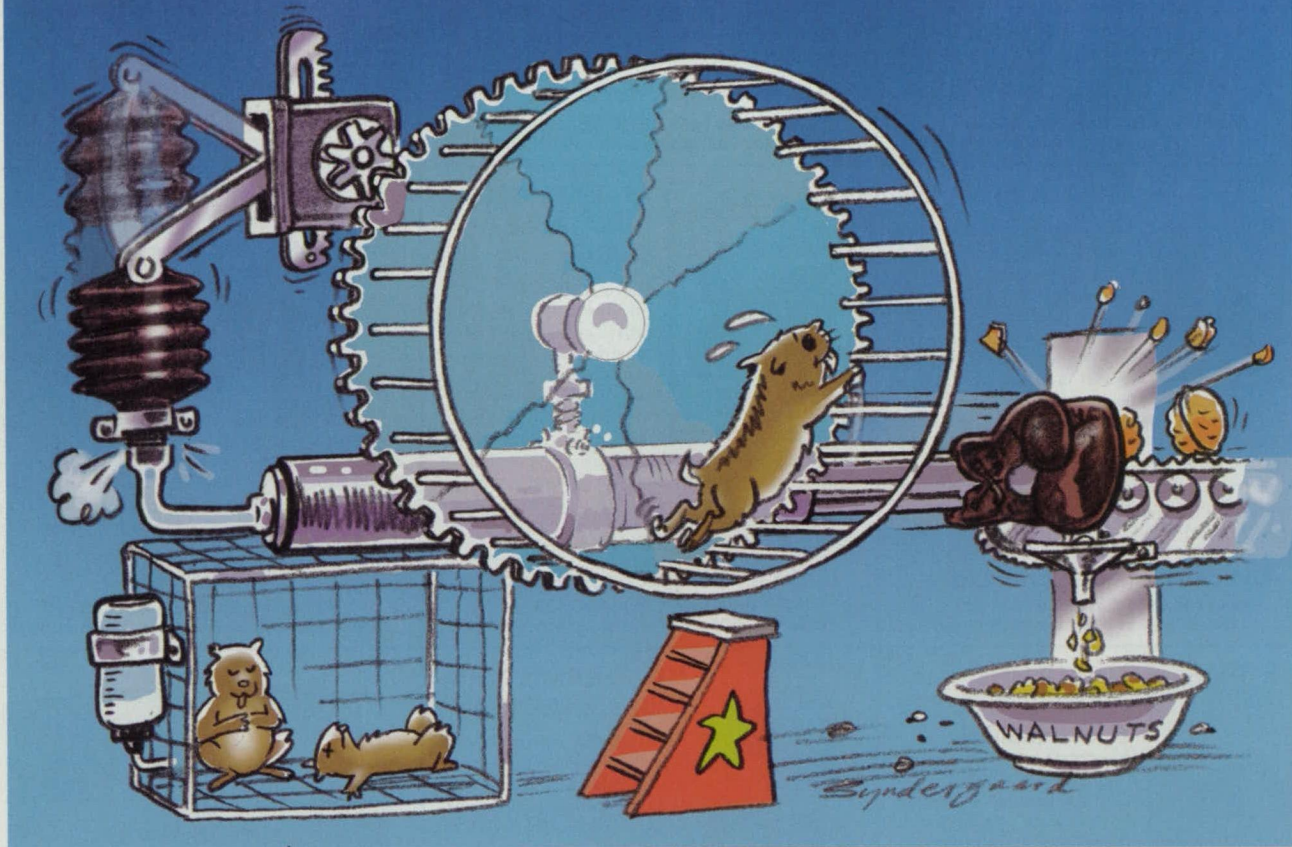
## Data Acquisition/Instruments

A CD Databook from Newport Electronics, Santa Ana, CA, provides thousands of pages of reference material, specifications, and manuals for the i™ Series panel meters, controllers, and signal conditioners with an embedded Web server. The Databook includes free software for data acquisition and configuring of Newport instruments, free ActiveX controls, and a free OPC server. **For Free Info Circle No. 715 or Enter No. 715 at [www.nasatech.com/rs](http://www.nasatech.com/rs)**





# Is Your Machine Still Running Around In Circles?



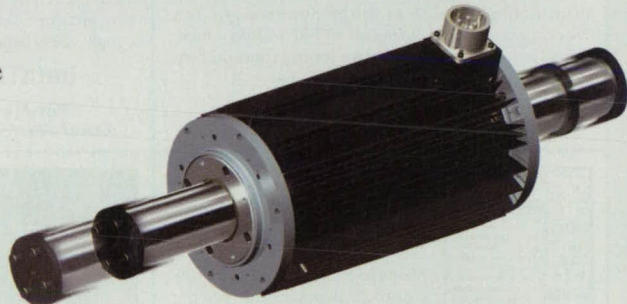
## Straighten it out with the CLD Linear Motor

If your linear motion system is spinning out of control, you're not alone. That can happen when you try to obtain precision linear motion using rotary technology.

Now, there's a high-tech solution – the compact tubular linear motor from California Linear Devices:

- Brushless, direct-drive technology.
- A single moving part – no cams, gears or pulleys.
- Integral bearing system.
- Fully programmable move profiles.
- Forces from 50 to 1,200 lb.
- Velocity to 100 in./sec.
- Strokes from 2 to 20 in.

So leave the rotary world behind, and you'll never look back.  
Call us today at (877) 474-2854 or visit [www.calinear.com](http://www.calinear.com).



**CLD**

*California Linear Devices, Inc.*

2236 Rutherford Road, Suite 119  
Carlsbad, CA 92008  
Phone: (760) 603-8026  
Fax: (760) 603-0049  
Toll Free: (877) 474-2854  
E-mail: [sales@calinear.com](mailto:sales@calinear.com)  
[www.calinear.com](http://www.calinear.com)





## DATA ACQUISITION AND INSTRUMENTATION eCATALOG

This free 37-page short-form catalog from IOtech features product overview charts and selection guides for IOtech's wide range of data acquisition systems and signal conditioning options. New products include the ScanWare™ family of products for Ethernet-based data acquisition and a new multi-function, 8-channel counter/encoder module for the portable data acquisition systems. IOtech, Inc.; Tel: 440-439-4091; Fax: 440-439-4093; email: sales@iootech.com; website: www.iootech.com

**IOtech, Inc.**

For Free Info Circle No. 601 or  
Enter No. 601 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

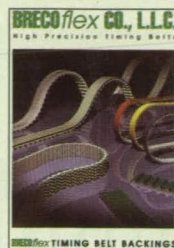


## MICRO-METALLIZER PLATING PROCESS

Low-Cost Disposable Applicators permit instantaneous selection from a variety of plating possibilities without preparation of solutions. Applications include goldfinger repair & rework, electronic instrument repair, prototype development work, etc. Available solutions: gold, silver, copper, nickel, palladium, rhodium, tin, zinc, chrome-color, black nickel. Hunter Products, Inc., Bridgewater, NJ 08807; Tel: 800-524-0692; Fax: 908-526-8348; website: [www.hunterproducts.com](http://www.hunterproducts.com); email: hunter@eclipse.net

**Hunter Products, Inc.**

For Free Info Circle No. 602 or  
Enter No. 602 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## HIGH PRECISION TIMING BELTS WITH BACK COVERS

BRECOflex Co., L.L.C. offers high-precision timing belts with backings in various thicknesses and with different ranges of hardness, diversity, abrasion, resistance, and coefficients of friction to suit your application. A full range of pulleys and other accessories also are available. For free catalogs, samples, or more info, call 732-460-9500 or visit our Website: [www.brecoflex.com](http://www.brecoflex.com) today.

**BRECOflex Co.**

For Free Info Circle No. 603 or  
Enter No. 603 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



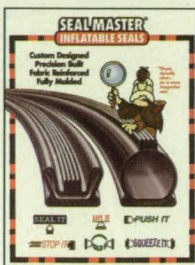
## FMEA SOFTWARE

Failure Modes and Effects Analysis using FMEA-Pro™ 5 empowers automotive, consumer, electronic, aerospace, defense and general manufacturing industries to improve the quality, reliability and safety of their products. This fully customizable

software helps companies comply with QS 9000, ISO 9000, SAE J1739, MIL-STD-1629, ISO/TS 16949 and other regulations. FMEA-Pro™ 5 contains extensive libraries and data protection features. The report generation tools support a variety of file formats, including HTML and PDF. Download a free trial: [www.fmeasoftware.com](http://www.fmeasoftware.com).

**Dyadem International Ltd.**

For Free Info Circle No. 604 or  
Enter No. 604 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

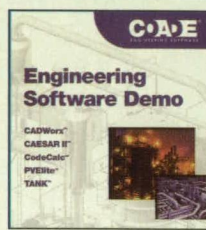


## SEAL MASTER INFLATABLE SEALS

Solve difficult design problems! Custom-built, fabric-reinforced elastomeric seals offer innovative solutions where gaps exist in sealing weather, liquids, temperature, light/dark pressure/vacuum, radiation, and contaminants. Use anywhere a positive seal is needed between opposing surfaces. Design assistance available. Seal Master Corporation, 368 Martinel Dr., Kent, OH 44240-4368; Tel: 800-477-8436; [www.sealmaster.com](http://www.sealmaster.com)

**Seal Master Corporation**

For Free Info Circle No. 605 or  
Enter No. 605 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## ENGINEERING SOFTWARE DEMO

COADE offers a free demonstration CD that illustrates its plant design and analysis programs. Walkthrough demonstrations describe software for mechanical design and analysis of piping systems and pressure vessels, piping CAD, and oil storage tank design. Executable demonstrations are included to provide "hands-on" evaluation of these popular packages. Contact us at 281-890-4566, 800-899-8787, or [sales@coade.com](mailto:sales@coade.com). Visit our Web site at [www.coade.com](http://www.coade.com)

**COADE, Inc.**

For Free Info Circle No. 606 or  
Enter No. 606 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## POWER LINE FILTERING & SURGE SUPPRESSION SYSTEMS

Control Concepts offers a broad range of power line filters and state-of-the-art surge suppression to meet all of your power quality needs. Control Concepts has products that make it easy and cost-effective to safeguard any electronic equipment from malfunction, downtime, or failure. Send for a FREE brochure and our handy informational guide to Surge Suppression and Filtering or call us toll free at: 877-523-7185; e-mail: [info@control-concepts.com](mailto:info@control-concepts.com); [www.control-concepts.com](http://www.control-concepts.com)

**Control Concepts**

For Free Info Circle No. 607 or  
Enter No. 607 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

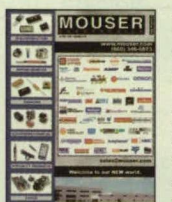


## NTC THERMISTORS AND ASSEMBLIES

BetaTHERM manufactures NTC thermistors with an interchangeability accuracy as tight as  $\pm 0.05^\circ\text{C}$  with time constants as fast as 20 ms. These devices are capable of operating over a range of  $-80^\circ\text{C}$  to  $+300^\circ\text{C}$ . Many of the thermistors are designed into custom probes to measure air, surface and liquid temperature. The probe housings can be made from stainless steel, brass, or copper materials to withstand hostile and corrosive environments. BetaTHERM Corporation; Tel: 508-842-0516; Fax: 508-842-0748; e-mail: [sales@betatherm-usa.com](mailto:sales@betatherm-usa.com); [www.betatherm.com](http://www.betatherm.com)

**BetaTHERM Corporation**

For Free Info Circle No. 608 or  
Enter No. 608 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

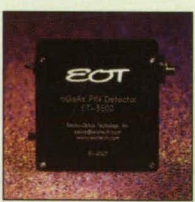


## ELECTRONIC COMPONENTS DISTRIBUTOR

Mouser Electronics provides complete product and pricing data for over 107,000 components from 200+ leading suppliers: AMP, Fairchild, Kemet, Phoenix Contact, Seiko, STMicroelectronics, Nichicon, Vishay, and more. Our web site offers secure online ordering, downloadable catalog, data sheets, search capabilities, and much more. Mouser Electronics, Inc., A TTI Inc. Company, 1000 N. Main St., Mansfield, TX 76063-1511; Tel: 817-804-3888 or 800-346-6873; Fax: 817-804-3899; e-mail: [catalog@mouser.com](mailto:catalog@mouser.com); [www.mouser.com](http://www.mouser.com)

**Mouser Electronics, Inc.**

For Free Info Circle No. 609 or  
Enter No. 609 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## 10GHZ InGaAs PHOTODETECTOR

Electro-Optics Technology, Inc. introduces the ET-3500 InGaAs photodetector. The ET-3500 is a battery biased photodetector with a bandwidth of DC to  $>10\text{GHz}$ . Rise time is  $<20\text{ps}$  and fall time is  $<30\text{ps}$ . The ET-3500 has a FC/APC input connector and an SMA output connector. The spectral range of the ET-3500 is 1000-1650nm. The price is \$1,595. Electro-Optics Technology, Inc., 1030 Hastings St., Ste. 140, Traverse City, MI 49686; Tel: 231-935-4044; Fax: 231-935-4046; [www.eotech.com](http://www.eotech.com)

**Electro-Optics Technology, Inc.**

For Free Info Circle No. 610 or  
Enter No. 610 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



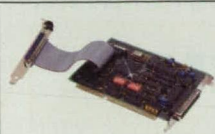
## NASA 2002 Calendar

Each month features a striking, colorful space photo — Shuttle launches, astronauts in action, planets, and more. Includes historic dates in space flight and amazing NASA facts. Special bonus: a complete photo collection of all human space flight patches. Fun and educational! \$9.50

**Order online:**

[www.nasatech.com/store](http://www.nasatech.com/store)





## LOW-COST 12-BIT DATA ACQUISITION SYSTEM

OMEGA's DAQ-801/802

is a low-cost data acquisition system with 12-bit resolution, eight-channel analog input, two-channel D/A output, 32-bit digital I/O, and one 16-bit programmable timer/counter for ISA bus computers (IBM PC/AT or compatible). The maximum sampling rate is 40 KHz for A/D with internal or external triggering. The DAQ-801/802 offers software-selectable, eight-channel, single-ended or differential analog inputs with 12-bit resolution. OMEGA Engineering, One Omega Dr., Stamford, CT 06907; Tel: 1-888-TC-OMEGA; [www.omega.com](http://www.omega.com)

### OMEGA Engineering Inc.

For Free Info Circle No. 611 or  
Enter No. 611 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

## INSTRUNET SERIES DIRECT SENSOR TO DATA ACQUISITION



instruNet provides 10s of microvolts of absolute accuracy instead of 10s of millivolts. Analog electronics are close to the sensor in electrically quiet boxes outside your PC. The external boxes contain signal-conditioning amplifiers for each channel. The box returns engineering units to your PC. OMEGA Engineering, One Omega Dr., Stamford, CT 06907; Tel: 1-888-TC-OMEGA; [www.omega.com](http://www.omega.com)

### OMEGA Engineering Inc.

For Free Info Circle No. 612 or  
Enter No. 612 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## EIS EMBEDDED INTERNET SERVER

Connect Your DRX Modules through an Ethernet Connection. The EIS Embedded Internet module is a standalone

device that will allow you to connect to your DRX modules through an Ethernet connection. The EIS module is a DIN rail device that can be a hub connecting up to 32 instruments to the Ethernet and Internet. The EIS module is both a Web Server and an Ethernet-Serial bridge. OMEGA Engineering, One Omega Dr., Stamford, CT 06907; Tel: 1-888-TC-OMEGA; [www.omega.com](http://www.omega.com)

### OMEGA Engineering Inc.

For Free Info Circle No. 613 or  
Enter No. 613 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## RUGGED, PORTABLE DATALOGGING SYSTEMS

OM-3000 Series data-

loggers take making measurements and downloading them to your PC for further analysis or archiving extremely easy. Input ranges, user-defined session names and sampling intervals are easily programmed via the built-in keypad. With the standard 128K memory, approximately 100,000 individual samples with date/time stamp can be stored in the datalogger for downloading. OMEGA Engineering, One Omega Dr., Stamford, CT 06907; Tel: 1-888-TC-OMEGA; [www.omega.com](http://www.omega.com)

### OMEGA Engineering Inc.

For Free Info Circle No. 614 or  
Enter No. 614 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## PORTABLE, LOW-COST DATALOGGERS

OM-40 Series dataloggers can record temperature, relative humidity, 4 to 20 mA and 0 to 2.5 Vdc signals. Model OM-41 measures temperature only; Model

OM-42 is a two-channel datalogger that measures temperature; Model OM-43 measures temperature and relative humidity; and Model OM-44 is a four-channel datalogger that measures temperature and relative humidity. OMEGA Engineering, One Omega Dr., Stamford, CT 06907; Tel: 1-888-TC-OMEGA; [www.omega.com](http://www.omega.com)

### OMEGA Engineering Inc.

For Free Info Circle No. 615 or  
Enter No. 615 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## PERSONAL DAQ USB DATA ACQUISITION MODULES

The OMB-DAQ-55 and OMB-DAQ-56 Personal Daqs are full-featured data acquisition products that utilize the Universal Serial Bus (USB), which is built into almost every new PC.

Designed for high accuracy and resolution, the 22-bit OMB-DAQ-55/56 data acquisition systems directly measure multiple channels of voltage, thermocouple, pulse, frequency, and digital I/O. OMEGA Engineering, One Omega Dr., Stamford, CT 06907; Tel: 1-888-TC-OMEGA; [www.omega.com](http://www.omega.com)

### OMEGA Engineering Inc.

For Free Info Circle No. 616 or  
Enter No. 616 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## 4-CHANNEL TEMPERATURE DATALOGGER

The OM-CP-QUADTEMP is a 4-channel, battery

powered, standalone, thermocouple-based temperature datalogger. This all-in-one, compact, portable, easy to use device will measure and record up to 122,000 temperature measurements (24,575 readings per channel). OMEGA Engineering, One Omega Dr., Stamford, CT 06907; Tel: 1-888-TC-OMEGA; [www.omega.com](http://www.omega.com)

### OMEGA Engineering Inc.

For Free Info Circle No. 617 or  
Enter No. 617 at [www.nasatech.com/rs](http://www.nasatech.com/rs)

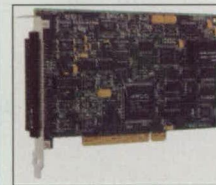
## WIRELESS THERMOCOUPLE TEMPERATURE TRANSMITTER



The OM-CP-RFTC4000 is a miniature, wireless, battery powered, standalone, thermocouple-based temperature transmitter. This all-in-one, compact, portable, easy to use device will measure and transmit temperature measurements. It can be started and stopped instantly through an externally accessible pushbutton. OMEGA Engineering, One Omega Dr., Stamford, CT 06907; Tel: 1-888-TC-OMEGA; [www.omega.com](http://www.omega.com)

### OMEGA Engineering Inc.

For Free Info Circle No. 618 or  
Enter No. 618 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



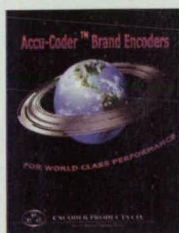
## PCI BUS 16-CHANNEL ANALOG INPUT BOARD

The PCI-DAS 1001 and PCI-DAS 1002 multifunction analog

and digital I/O boards set a new standard for low-cost, medium-speed data acquisition on the PCI bus for IBM or compatible PCs. It offers 16 single-ended or 8 differential 12-bit analog inputs with sample rates up to 150 KHz, 24 bits of digital I/O and three 16-bit counters. In addition, the PCI-DAS 1000 series offers two 12-bit analog outputs. OMEGA Engineering, One Omega Dr., Stamford, CT 06907; Tel: 1-888-TC-OMEGA; [www.omega.com](http://www.omega.com)

### OMEGA Engineering Inc.

For Free Info Circle No. 619 or  
Enter No. 619 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## PRECISION ENCODERS

New 98-page catalog gives in-depth specifications and descriptions of Accu-Coder™ brand encoders by Encoder Products Company. Catalog features a full line of Cube™, industry-standard size 15, size 20, size 25, size 58mm, C-face, NEMA mount and hollow shaft encoders, with a wide selection of configuration options, suitable for a wide variety of industrial counting, motion, and motor control applications. Encoder Products Company; Tel: 800-366-5412; Fax: 208-263-0541; [www.encoderproducts.com](http://www.encoderproducts.com)

### Encoder Products Company

For Free Info Circle No. 620 or  
Enter No. 620 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## NEW! PEM PFF™ FLOATING PANEL FASTENERS

Newly introduced Type PFF™ floating panel fasteners from PEM® Fastening Systems provide radial "float" to compensate for mating hole misalignment up to 0.060"/1.52mm and can be installed into any panel material. These new panel fasteners utilize a washer for easy installation with a flared punch into sheets as thin as 0.031"/0.79mm. PEM Fastening Systems, A PennEngineering Company; Tel: 800-237-4736; Fax: 215-766-0143; [www.pemnet.com](http://www.pemnet.com)

### PEM Fastening Systems, A PennEngineering Company

For Free Info Circle No. 621 or  
Enter No. 621 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



## FREE MEASUREMENT & AUTOMATION CATALOG 2002

The National Instruments Measurement and Automation Catalog 2002 is the leading resource for engineers and scientists seeking the most effective customer-defined measurement and automation solutions. You will find everything you need from product specifications to comprehensive tutorials, comparison charts to selection advice and related references. For a free copy, call or visit [www.ni.com/info](http://www.ni.com/info) and enter na6m40.

### National Instruments

For Free Info Circle No. 622 or  
Enter No. 622 at [www.nasatech.com/rs](http://www.nasatech.com/rs)



# FREE INFORMATION REQUEST FORM

## For quickest service:

**Fax** this form to (413) 637-4343

**Use the online** reader service center at  
[www.nasatech.com/rs](http://www.nasatech.com/rs)

**Or mail** your completed form to  
**NASA Tech Briefs,**  
PO Box 5077, Pittsfield, MA 01203-9109.

Name: \_\_\_\_\_

Company: \_\_\_\_\_

Address: \_\_\_\_\_

City/St/Zip: \_\_\_\_\_

Phone: \_\_\_\_\_

Fax: \_\_\_\_\_

e-mail: \_\_\_\_\_

Please tell us below how *NASA Tech Briefs* has helped you solve a problem or been applied to your business/product line.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Do you currently receive *NASA Tech Briefs*? ☐ Yes ☐ No

If no, would you like to receive *NASA Tech Briefs*? ☐ Yes ☐ No

## ARE YOU AN INSIDER?

Subscribe today to receive the INSIDER, a FREE e-mail newsletter from *NASA Tech Briefs*. The INSIDER features exclusive previews of upcoming articles...late-breaking NASA and industry news...hot products and design ideas...links to online resources...and much more.

☐ I want to be an INSIDER. Send my newsletter to the following e-mail address:

\_\_\_\_\_  
Name \_\_\_\_\_

Company \_\_\_\_\_

I also want to receive special-focus e-newsletters on the following technology topics: (check all that apply)

- |                                  |  |
|----------------------------------|--|
| <input type="checkbox"/> CAD/CAE | <input type="checkbox"/> Fiber Optics/Communications |
| <input type="checkbox"/> Lasers  | <input type="checkbox"/> Test & Measurement          |
| <input type="checkbox"/> Optics  | <input type="checkbox"/> Imaging/Cameras             |
| <input type="checkbox"/> Sensors |  |

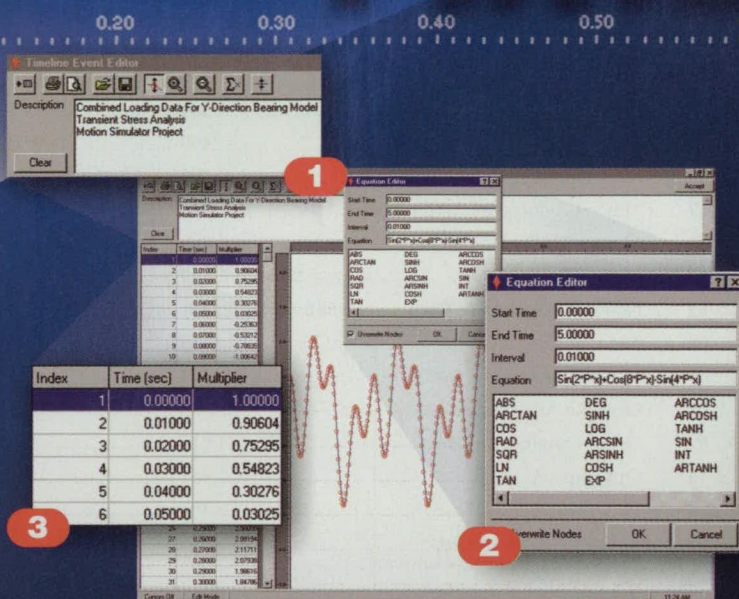
**For fastest service, sign up online**  
**at [www.nasatech.com/insider](http://www.nasatech.com/insider)**

Circle the numbers below to receive more information about products and services featured in this issue.

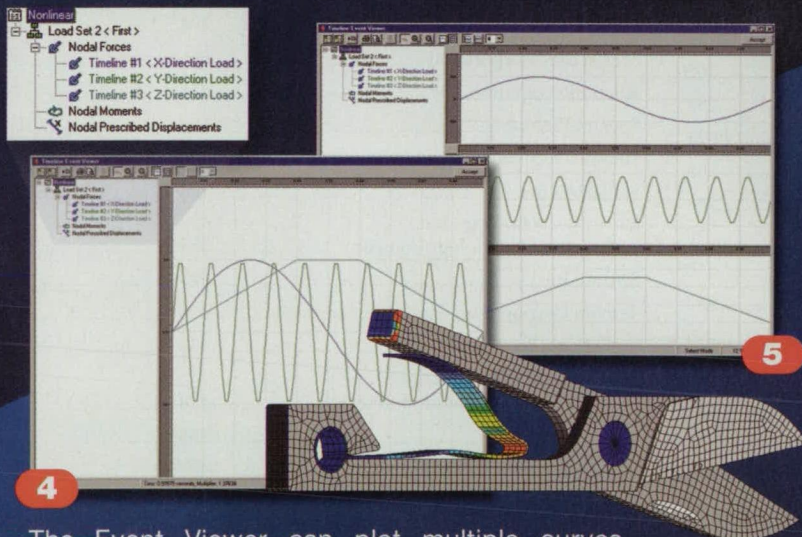
401	402	403	404	405	406	407	408	409	410
411	412	413	414	415	416	417	418	419	420
421	422	423	424	425	426	427	428	429	430
431	432	433	434	435	436	437	438	439	440
441	442	443	444	445	446	447	448	449	450
451	452	453	454	455	456	457	458	459	460
461	462	463	464	465	466	467	468	469	470
471	472	473	474	475	476	477	478	479	480
481	482	483	484	485	486	487	488	489	490
491	492	493	494	495	496	497	498	499	500
501	502	503	504	505	506	507	508	509	510
511	512	513	514	515	516	517	518	519	520
521	522	523	524	525	526	527	528	529	530
531	532	533	534	535	536	537	538	539	540
541	542	543	544	545	546	547	548	549	550
551	552	553	554	555	556	557	558	559	560
561	562	563	564	565	566	567	568	569	570
571	572	573	574	575	576	577	578	579	580
581	582	583	584	585	586	587	588	589	590
591	592	593	594	595	596	597	598	599	600
601	602	603	604	605	606	607	608	609	610
611	612	613	614	615	616	617	618	619	620
621	622	623	624	625	626	627	628	629	630
631	632	633	634	635	636	637	638	639	640
641	642	643	644	645	646	647	648	649	650
651	652	653	654	655	656	657	658	659	660
661	662	663	664	665	666	667	668	669	670
671	672	673	674	675	676	677	678	679	680
681	682	683	684	685	686	687	688	689	690
691	692	693	694	695	696	697	698	699	700
701	702	703	704	705	706	707	708	709	710
711	712	713	714	715	716	717	718	719	720
721	722	723	724	725	726	727	728	729	730
731	732	733	734	735	736	737	738	739	740
741	742	743	744	745	746	747	748	749	750
751	752	753	754	755	756	757	758	759	760
761	762	763	764	765	766	767	768	769	770
771	772	773	774	775	776	777	778	779	780
781	782	783	784	785	786	787	788	789	790
791	792	793	794	795	796	797	798	799	800
801	802	803	804	805	806	807	808	809	810
811	812	813	814	815	816	817	818	819	820
821	822	823	824	825	826	827	828	829	830
831	832	833	834	835	836	837	838	839	840



# TIMELINE



Timeline's Event Editor provides click-and-drag points for easy curve definition as well as: **1** export functionality and a library manager; **2** Equation Editor for curve creation from designated inputs and **3** tabular entry for curve data.



The Event Viewer can plot multiple curves **4** together or **5** separately to show how multiple physical phenomena will simultaneously act on a model during analysis.

ALGOR's Timeline Event Manager graphical utility enables engineers to quickly and easily define and visualize time-based event curves for Mechanical Event Simulation, transient structural analysis and transient thermal analysis. It simplifies the setup of complex real-world events by simultaneously plotting curves for multiple analysis types to show exactly how variables will interact.

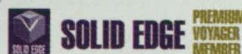
## TIMELINE EVENT MANAGER FOR:

- Mechanical Event Simulation (MES)
- Transient Structural Analysis with Linear and Nonlinear Material Models
- Transient Thermal Analysis

- Graphical visualization of curve data helps engineers catch input errors during analysis setup.
- A built-in Equation Editor uses start times, end times and a library of supported functions to generate event curves.
- Built-in spreadsheet provides fast entry or modification of magnitude versus time data.
- Multiple load curves can be depicted on a single plot in the Event Viewer for multiphysics analyses.
- Points on any plot can be dynamically dragged to new locations.
- Timeline integrates with Microsoft applications including Excel.
- A library stores frequently referenced, user-defined curves.
- Timeline works within CAD for a value-added modeling solution.



Watch a free Internet Webcast at **eventmgr.ALGOR.com** to learn about the Timeline Event Manager for performing time-dependent and multiphysics analyses with ALGOR software.



When Engineering Has to be Right

US Phone: 1.412.967.2700  
 Europe (UK): 44.1784.442.246  
 Fax: 1.412.967.2781  
 California: 1.714.564.0844  
 eventmgr.algor.com  
 www.algor.com  
 E-mail: eventmgr@algor.com  
 150 Beta Drive,  
 Pittsburgh, PA 15238-2932 USA



# Advertisers Index

For free product literature from these advertisers, enter their reader service numbers at [www.nasatech.com/rs](http://www.nasatech.com/rs)

Advertisers listed in bold-face type have banner ads on the NASA Tech Briefs Web site — [www.nasatech.com](http://www.nasatech.com)

Company	Reader Service Number	Page	Company	Reader Service Number	Page
Abaris Training Resources.....	425	57	<b>Master Bond Inc.</b> .....	<b>427</b>	<b>58</b>
Accuride International Inc. ....	412	34-35	MathSoft Engineering & Education, Inc. ....	533	31
Aerotech, Inc. ....	455	16a	<b>The MathWorks, Inc.</b> .....	<b>564</b>	<b>13</b>
<b>Algor, Inc.</b> .....	<b>595, 596, 593</b>	<b>7, 47, 65</b>	Matrox Imaging .....	450	COV IIa
Ansoft .....	566	33	Melles Griot .....	461	10a
<b>Astro-Med, Inc.</b> .....	<b>525</b>	<b>17</b>	Minco Products, Inc. ....	424	55
Autodesk, Inc. ....	542	15	Mouser Electronics, Inc. ....	609	62
W.M. Berg, Inc. ....	431	57	<b>MSC Software</b> .....	<b>559, 557</b>	<b>43, COV III</b>
BetaTHERM Corporation .....	608	62	<b>National Instruments Corp.</b> .....	<b>562, 415, 622, 451</b>	<b>COV II, 38, 63, 4a</b>
BRECOflex Co., L.L.C. ....	603	62	NM Laser Products, Inc. ....	489	25a
California Linear Devices, Inc. ....	526	61	Noran Engineering, Inc. ....	404	18
Cargille Laboratories Inc. ....	437	54	Olympus America, Inc. ....	493	3a
COADE, Inc. ....	606	62	Omega Engineering, Inc. ....	501, 611-619	1, 63
Coherent, Auburn Division.....	500	7a	OptoSigma .....	482	13a
Compaq Computer Corporation .....	531	9	Oz Optics Ltd. ....	497	9a
Control Concepts.....	607	62	PEM Fastening Systems- A PennEngineering Company .....	621	63
<b>Cosmos™</b> .....	<b>512</b>	<b>21</b>	Photron USA .....	418	46
Digi-Key Corporation.....	517	3	Polymer Sealing Solutions.....	423	50
Dolch Computer Systems, Inc. ....	570	29	Polymicro Technologies, LLC.....	449	26a
Duma Optronics Ltd., Israel .....	459	19a	Presray Corporation.....	411	42
DuPont, Vespel.....	545	37	Research Systems, A Kodak Company .....	401	8
Dyadem International Ltd. ....	604	62	<b>RGB Spectrum</b> .....	<b>402</b>	<b>12</b>
<b>Dymax</b> .....	<b>447</b>	<b>24a</b>	Roper Scientific .....	494	23a
EDS, Unigraphics.....	550	10-11	Seal Master Corporation .....	605	62
Electro-Optics Technology, Inc. ....	610	62	Silicon Recognition, Inc. ....	434	53
Electron Tubes Inc. ....	446	28a	Spectra-Physics .....	537, 538	1a, 17a
<b>Emhart, a Black &amp; Decker Company</b> .....	<b>405, 534</b>	<b>22-23</b>	Stanford Research Systems .....	544	59
Encoder Products Company.....	620	63	StellarNet Inc. ....	498	18a
FJW Optical Systems, Inc. ....	444	26a	StorCase Technology, Inc., a Kingston Technology Company .....	552	19
Fluke Corporation .....	413	39	Synrad, Inc. ....	523	2
Gage Applied, Inc. ....	403	16	Tescom Corporation .....	406	27
Harvard Thermal, Inc., Melcor Corp. ....	473	21a	TransLogic Incorporated .....	436	56
Hinds Instruments, Inc. ....	460	20a	U.S. Department of Energy, Small Business Innovation Research .....	428	60
Hunter Products, Inc. ....	602	62	UDT Instruments.....	453	6a
IBM, Dassault Alliance.....		26	Universal Switching Corporation .....	421	44
IBM, IntelliStation .....	560	COV IV	Velmex, Inc. ....	466	20a
<b>Indigo</b> .....	<b>485</b>	<b>5a</b>	Visual Numerics, Inc. ....	410	28
Innovative Integration .....	414	36	VX Corporation .....	546	4-5
Integrated Engineering Software .....	574	45	<b>yet2.com</b> .....	<b>20, 49, 6a, 15a</b>	
IOtech, Inc. ....	601	62	Zaber Technologies Inc. ....	486	25a
<b>Keithley Instruments, Inc.</b> .....	<b>571</b>	<b>41</b>	ZC & R .....	475	11a
Lake Shore Cryotronics, Inc. ....	426	58	<b>Z•World</b> .....	<b>422</b>	<b>55</b>
Litton Airtron Synoptics .....	454	14a			
Magnetic Shield Corp.....	430	48			

NASA Tech Briefs, ISSN 0145-319X, USPS 750-070, copyright ©2001 in U.S. is published monthly by Associated Business Publications Co., Ltd., 317 Madison Ave., New York, NY 10017-5391. The copyright information does not include the (U.S. rights to) individual tech briefs that are supplied by NASA. Editorial, sales, production, and circulation offices at 317 Madison Ave., New York, NY 10017-5391. Subscription for non-qualified subscribers in the U.S., Panama Canal Zone, and Puerto Rico, \$75.00 for 1 year; \$135 for 2 years. Single copies \$5.00. Foreign subscriptions one-year U.S. Funds \$195.00.

Remit by check, draft, postal, express orders or VISA, MasterCard, and American Express. Other remittances at sender's risk. Address all communications for subscriptions or circulation to NASA Tech Briefs, 317 Madison Ave., New York, NY 10017-5391. Periodicals postage paid at New York, NY and additional mailing offices.

POSTMASTER: Send address changes to NASA Tech Briefs, PO Box 10523, Riverton, NJ 08076-9023.



*Tarantula Hawk Wasp (Hemipepsis)*



DOMINATE YOUR ENVIRONMENT,  
ONE CLUSTER AT A TIME.



#### INTRODUCING CLUSTERING TECHNOLOGY FOR THE REAL WORLD

In nature, those who have a unique edge over the competition will dominate their arena. At MSC.Software our complete turnkey systems give you the advantage you're looking for. They are designed for the most demanding computational environments by optimizing the hardware, O/S, middleware and applications. Our advanced MSC.Linux operating system and clustering technology offer an extremely cost-effective customized solution that will get your process moving. Support is always just a phone call away at one of our over 50 offices worldwide. Call us today. It's your environment, dominate it.

For more information call 1.800.642.7437, ext.2500. Or visit [www.msclinux.com/wasp](http://www.msclinux.com/wasp).

MSC SOFTWARE





# Ludicrous speed.



IntelliStation M Pro  
(Monitor sold separately.)

IBM IntelliStation® workstations deliver the speed you need to run the fast-paced software you require.

You need a brilliant machine that propels your ideas to extreme levels. IBM IntelliStation workstations deliver supreme performance at breakneck speeds with the most certified applications<sup>1</sup> in the industry. That's over 90 CAD apps that are continuously tuned by our dedicated team of engineers – you simply won't get that anywhere else! And with an Intel® Xeon™ processor, you can run that engineering software at the speed it demands. So, stretch your imagination all you want – in fact, it's encouraged. And should you have a question that needs rapid attention, just e-mail **Ask IntelliStation**<sup>2</sup> – an IBM expert will answer your hardware and application questions within 24 hours. It's that simple. Radical? No. Revolutionary? Yes. So call or click and check out IBM IntelliStation workstations today.



Get the latest product pricing and information fast.  
Use NavCode on the phone or on the Web.

## DIRECT TO YOU

Call toll free **1 866 723-5434** or  
Click **www.ibm.com/intellistation/M291**  
for more information, to buy direct or locate an IBM reseller.

### IBM IntelliStation E Pro

Affordable workstation power

Intel Pentium® 4 processor 1.80GHz  
128MB ECC memory  
Matrox G450 graphics  
40GB\* ATA/100 EIDE hard drive  
48X\* max CD-ROM  
Microsoft® Windows® 2000  
3-year parts/1-year labor limited warranty<sup>3</sup>

**\$1,889<sup>6</sup>**

▶ NavCode  
621420U-M291

**SuccessLease™ for Small Business \$67/mo.<sup>7, 36</sup> MOS.**

#### CUSTOMIZE YOURS:

**256MB 133MHz ECC SDRAM**

(Part #10K0046) \$159 or \$6/month

**9.4/4.7GB Stealth Black IDE DVD-RAM\***

(Part #10K3561) \$489 or \$17/month

### IBM IntelliStation M Pro

Ultimate workstation performance

Intel Xeon processor 1.70GHz  
512MB ECC memory  
ATI Fire GL4™ graphics  
18.2GB Ultra160 SCSI hard drive  
48X max CD-ROM  
Microsoft Windows 2000  
3-year parts/1-year labor limited warranty

**\$4,179**

▶ NavCode  
685025U-M291

**SuccessLease™ for Small Business \$139/mo.<sup>7, 36</sup> MOS.**

#### CUSTOMIZE YOURS:

**Additional Intel Xeon Processor 1.70GHz**

(Part #24P8402) \$699 or \$23/month

**IBM Spaceball 3D Input Device\***

(Part #33L3252) \$489 or \$17/month



\*For non-IBM software, applicable third-party licenses may apply. Warranty, service and support for non-IBM products, if any, are provided by third parties, not IBM. IBM makes no representations or warranties regarding non-IBM products. \*Requires Internet access account, not included. \*GB = 1,000,000,000 bytes when referring to storage capacity. Accessible capacity is less. \*CD and DVD drives list maximum rates; rates are variable and are often less than the maximum. \*For a copy of IBM's Statement of Limited Warranty, call 1 800 772-2227. Telephone support may be subject to additional charges. \*Prices do not include tax or shipping and are subject to change without notice. Reseller prices may vary. \*SuccessLease is offered by third-party providers of business financing approved by IBM Global Financing. SuccessLease terms and conditions provided by the third party. Featured monthly lease payments include pre-specified purchase option at end of lease, to qualified business customers only, installing in the US. Documentation fee and first month's payment due at lease signing, taxes are additional. Offer may be withdrawn or changed without notice. Options cannot be leased separately. \*Writes single-sided 4.7GB DVD-RAM disc or double-sided 9.4GB DVD-RAM disc at 2.77MB/sec and writes single-sided 2.6GB DVD-RAM disc or double-sided 5.2GB DVD-RAM disc at 1.38MB/sec. Reads DVD-RAM and DVD-ROM media at up to 8.3MB/sec. \*IBM does not manufacture, warrant or support this product; IBM logos and trademarks used under license. Contact IBM for details. All offers subject to availability. IBM reserves the right to alter product offerings and specifications at any time, without notice. IBM cannot be responsible for photographic or typographic errors. IBM makes no representations or warranties regarding third-party products or services. SuccessLease and all IBM product names are trademarks or registered trademarks of International Business Machines Corporation. Intel, the Intel Inside logo and Pentium are registered trademarks and Xeon is a trademark of Intel Corporation or its subsidiaries in the United States and other countries. Microsoft and Windows are registered trademarks of Microsoft Corporation. Fire GL4 is a trademark of ATI Technologies, Inc., and is used under license. Other company, product and service names may be trademarks or service marks of others. ©2001 IBM Corp. All rights reserved.

For Free Info Circle No. 560 or Enter 560 at [www.nasatech.com/rs](http://www.nasatech.com/rs)